Catfish creek conservation report 1951

Ground water
Forestry

Ontario

DEPARTMENT OF PLANNING AND DEVELOPMENT

SPRINGWATER POND

This beautiful pond on Bradley Creek is one of the loveliest spots on the Catfish Watershed. The pond itself is over a quarter of a mile long and surrounded by magnificent woodland. The woods are one of the few unspoiled areas of Southern Ontario and here may be seen majestic oaks, pines and maples standing in all their primitive splendour as they have done for three hundred years and more. This pond and the land surrounding it are the greatest assets of the Catfish Watershed, for they not only provide recreational facilities such as swimming, boating, fishing and nature study, but are a very important source of water to the stream itself. The magnificent woods, too, could be made, under proper forest management, a great source of revenue from the sale of timber.

Ontario. Planning and Development, Dept. of

(DEPARTMENT OF PLANNING AND DEVELOPMENT

THE HONOURABLE WM. GRIESINGER, MINISTER

A. H. RICHARDSON, CHIEF CONSERVATION ENGINEER)

CATFISH CREEK CONSERVATION REPORT

(pt. 1. GROUND WATER

pt. 2. FORESTRY)

ONTARIO

TORONTO
1951

LETTER OF TRANSMITTAL

The Honourable William Griesinger, Minister,
Department of Planning and Development,
Parliament Buildings,
Toronto, Ontario.

Honourable Sir:

I take pleasure in transmitting herewith a Conservation Report on the Catfish Creek Valley, in two sections namely Forestry and Ground Water.

Yours very truly,

A. H. Richardson
Chief Conservation Engineer

Toronto, November 22, 1951

Note to Second Edition

The first edition of this report was made up of twelve copies which contained many maps and profiles of a technical nature for use with the section on Ground Water. These were distributed to the members of the Authority and persons directly concerned with the technical study.

In this edition the most pertinent information has been consolidated in the map following page 76, and the remainder of the maps, profile sections and a number of the illustrations have been omitted.

Forty copies of this second edition have been prepared, of which this is

Number 26

T H E   C A T F I S H   C R E E K
C O N S E R V A T I O N   A U T H O R I T Y

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Vice-Chairman	HAROLD A. WHITE	Aylmer
Chief Officer	A.H. RICHARDSON, P.Eng.	Toronto
Secretary-Treasurer	D.M. HALPENNY	Aylmer

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In this second edition of the Catfish Report, technical maps and profiles have been omitted. One coloured map showing the political and main topographical features is added.

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RECOMMENDATIONS

STATED OR IMPLIED IN THIS REPORT

Ground Water

1. That the location of any new high production wells in the watershed should be determined by consultation with a competent geologist, taking into account the geological structure of the area concerned and the records of wells previously drilled. pp. 61-62
2. That the Authority should seek the co-operation of well-drillers and well-owners, for the purpose of making their well logs useful to the Authority by providing information regarding the geological structure of the area concerned. pp. 38-39
3. That no new high production artesian wells should be drilled in the watershed in areas where the artesian pressure of sulphurous, oily, or salt water is higher than the pressure of adjacent fresh-water aquifers. p. 46
4. That no fresh-water wells in the watershed should be drilled down to bedrock or to the gravel layer just above it. p. 49
5. That wells for the supply of water to the Town of Aylmer should not be located in the areas north-west, west, south-west, or south-east of that town, or in the area between Aylmer Town Wells Nos. 3 and 3A. p. 61
6. That the area north-east or east-north-east of Aylmer Town Wells Nos. 3 and 3A is probably the most favourable for new supplies of water for the Town of Aylmer. p.62
7. That well-drilling operations that encounter sulphurous water should be abandoned, leaving the entire length of drill casing in the ground. p.49

8. That high production wells should be spaced far enough apart so that the drawdown of any one of them does not affect the water level in any other. p. 62

9. That high production wells should be so planned as to make use of the available knowledge of ground-water aquifers, in order to distribute as widely as possible their exploitation. p. 53

10. That the Town of Aylmer should undertake a project for the purpose of restoring the ground-water supply in their vicinity by artificial recharge from the waters of Catfish Creek, using the method of pits filled with gravel, combined with still-pools for the partial removal of silt from the creek-waters. p.74

11. That the Authority should promote the re-forestation of approved areas in the watershed in order to check the falling of the ground-water levels, or to restore them. p.53

<u>Forestry</u>

12. That the Catfish Forest of about 2,800 acres, comprising seven areas of marginal and sub-marginal land, be established by the Authority to protect the natural water-storage areas of the watershed and make the best use of land which is suitable only for the growing of trees. p. 36

13. That the Authority expropriate all tax delinquent land subject to the regulations of the Municipal Act. p.53

14. That natural regeneration be encouraged wherever possible and that open areas be planted where necessary. p.40

15. That reforestation of privately owned land be encouraged in every way possible, particularly on sandy, gravelly, and poorly drained soils and on slopes too steep for agriculture. p. 28

16. That the Authority inaugurate a scheme to aid farmers in fencing their woodlots similar to that adopted by the County of Halton. p. 43

17. That counties and smaller municipalities be encouraged to establish forests within the watershed. p.29

18. That the policy of encouraging schools to enter the Provincial School Forestry Competitions, as adopted by the District Foresters, be supported by the Authority. p. 34

GROUND WATER

G R O U N D   W A T E R

CHAPTER 1

INTRODUCTION

The Ground Water Section of this report deals with:

(a) Pleistocene deposits

(b) Ground-water resources in them and

(c) Possibilities of their recharge in that part of the Catfish Creek Watershed which is north-east of Aylmer

The geological and ground-water studies of the above-mentioned area were a part of the systematical survey of Catfish Creek Watershed, carried out by the Conservation Branch of the Ontario Department of Planning and Development.

Field work - collecting of well information, surveying and geological mapping - was done by the author of this paper and his two assistants, L. Pretty and I. Tomlinson, during the summer of 1950. Data about 510 water wells, 26 test holes and 100 gas wells were gathered. (Well numbers in profile sections and descriptions correspond to their numbers in files.) Their elevation was determined by a level, using bench-marks of Highway No. 3, except of those gas wells with known elevation. All available exposures of pleistocene deposits of the mapped area, either natural or artificial, were studied. Test holes were dug or hand-borings made by an auger down to a depth of 2 to 10 feet in places without exposures. As the mapped area had only a few deeper exposures, the geological survey was extended to the Catfish Creek Valley between Aylmer and Lake Erie, as well as to the Lake Erie shore south of Aylmer and the Otter Creek south-east from the mapped area. (Numbers of exposures, mentioned in the text or profile sections, in brackets, correspond to the numbers in the field-book.)

In order to study the ground-water recharge methods, the author of this paper was sent by Mr. A.H. Richardson to several places in the eastern United States, and information regarding this matter was collected from other parts of the United States. For a general discussion of ground water and glossary of pleistocene terms see the Water Supply Papers of the Geological Survey of Canada, Nos. 284, 285, 288, 290, 293.

The sincerest thanks are here expressed to everyone who supplied information for this section of the report or assisted in completing the field work or in gathering materials for comparison in both Canada and the United States.

CHAPTER 2

GEOMORPHOLOGY

The north-east part of the Catfish Creek Watershed, called the Aylmer-Brownsville area in this report, constitutes an elongated triangular field with its longest axis (about twelve miles) along the Catfish Creek. The narrow end of this area, about two miles wide, is east of Brownsville, while the wider west end is about six miles in width.

The central and largest part of this area is a wide depression with the same trend and shape as the whole area. It is bordered by two ridges of recessional moraines: the Norwich moraine along its north and north-west boundary and the Tillsonburg moraine along its south-east boundary. As mapping was done mainly up to the crest of these moraines, they appear merely in narrow strips, about one-third to two-thirds of a mile wide, along the above-mentioned boundaries of the geological map (Map 1).

1. The Norwich Moraine

The Norwich moraine (actually its southern branch) constitutes a high rim along the north boundary of the area (Photographs 12-14). It curves from the crossing of the Michigan Central Railway and the road between Lots 5 and 6 of Malahide Township up to half a mile south of Lyons and then on east-north-east, north of Brownsville. Its crest is lower at the west end, west of Aylmer Station on the M.C.Railway, where it is about 825 feet above sea level and 10 to 20 feet above the surrounding ground moraine. It gradually rises in the east-north-east direction up to about 930 feet above sea level north-west of Brownsville, and is between 900 feet and 925 feet at the extreme north-east corner of the map. The ridge is only 20 to 30 feet higher than the narrow depression north of it (outside of the mapping area), but it rises up to 100 to 130 feet above the wider Catfish Creek depression

south of it and is higher than the Tillsonburg moraine south of the depression. Thus it marks a natural boundary between the highlands north of it and the 100 to 200 feet lower land south of it, at least in the area between Springfield and Brownsville and south of there.

2. <u>The Tillsonburg Moraine</u>

The Tillsonburg moraine is lower, not exceeding 830 feet above sea level. Its crest is more irregular, with at least four higher parts, the highest one being also in the north-east. These four higher parts of the moraine can be seen best on the map of the Lake Whittlesey stage (Map 5), when they formed four islands in the glacial lake.

3. <u>The Aylmer-Brownsville Depression</u>

The depression between these two recessional moraines, called the Aylmer-Brownsville depression in this report (Photographs 15-16), is flat, with a general dip from about 840 feet above sea level at its north-east end down to about 730 feet at its south-west boundary. That means an average gradient of 9 feet per mile along the axis of the depression. Catfish Creek and Bradley Creek have cut their valleys into the bottom of the depression down to a depth of about 720 feet at the west margin of the area. This depression was occupied by arms of glacial lakes or mouths of spillways at the end of the Wisconsin Ice Age (Chapters 4 and 5), and thus it has a cover of younger deposits on the top of the glacial till.

In the west part of the depression (beginning with the area south-east of Glencolin and west from there) there are many abandoned flat, valley-like, poorly drained depressions. As most of them are along the south side, continuing towards Bradley Creek in the west, it is possible that the principal drainage of the Aylmer-Brownsville depression was formerly not along the present Catfish Creek but along Bradley Creek, e.g., during the Lake Warren time.

CHAPTER 3

GEOLOGICAL STRUCTURE

1. Bedrock Surface

The thickness of pleistocene deposits and some of their structural features depend greatly upon the depth and relief of the bedrock surface. The bedrock is Middle Devonian, Norfolk limestone, according to J.F. Caley's 1941 map (619A). Logs of gas wells record shale on the top of limestone in some places. Such "shale" may in reality have been soft weathered limestone.

Records of well drilling reveal a general dip of the bedrock surface in the south direction. The steepest dip is along the north-west, north and north-east boundary of the mapped area, and it seems to be partly due to the existence of valley-like depressions heading against these areas. The mapped area, however, is too small to reveal the larger trends of the above-mentioned valleys or other large-scale changes in the dip of the bedrock surface.

The valley-like depressions are broad with the steepest slope 1¼ miles east of Summers' Corners, about three miles north-north-west of Aylmer, and at Springfield. They show a branching pattern with their main parts trending south or south-west (at Aylmer), and may be relicts of preglacial valleys, with hill-like or ridge-like erosional remnants between them.

The main valley-like depression is between Springfield and Aylmer, crossing the map from its north boundary east of Lyons, down to Summers' Corners and past them in a south-south-east direction.

It is very often observed that buried bedrock valleys are favourable for accumulation of ground water, particularly if they are filled with pervious deposits (gravel, sand, etc.). No sure records of large amounts of fresh water are available from the bedrock depressions of the Aylmer-Brownsville area. It may be that they are filled mostly with till,

which, if clayey, is relatively impervious. The Carnation Company's three wells half a mile south-west of Springfield receive their water from a depth of 220 feet in the above-mentioned bedrock "valley" between Springfield and Aylmer, each yielding 125 gallons per minute. The water, however, is sulphurous. We could expect the accumulation of fresh water in at least some of the bedrock valleys; but long-time pumping tests would be necessary in our area to find out whether water is sulphurous along the bottom of these valleys or has a tendency to become sulphurous after intensive pumping.

2. Thickness of Pleistocene Deposits

The thickness of pleistocene deposits in the Aylmer-Brownsville area varies from 160 feet to about 325 feet. The greatest thickness is along the Tillsonburg moraine, particularly along the south margin of the mapped area. As the bedrock surface rises towards the north at a higher rate than the topographical surface, the Norwich moraine generally does not show as thick accumulation of glacial drift as does the Tillsonburg moraine. The greatest thickness along the Norwich moraine is where subglacial valleys cross the end moraine (between Lyons and Springfield, 300 to 320 feet).

The thinnest glacial cover (160 to 180 feet) is in a wide area south-west and east of Brownsville, with a thickening up to 220 feet along a subglacial depression south of Brownsville and under the Tillsonburg moraine south of it. Farther south-west the Catfish Creek depression has a relatively thicker cover, generally 220 to 240 feet, in the subglacial valley north and north-west of Aylmer even up to 300 feet.

Thus without taking into account the thickening of pleistocene deposits due to the formation of superficial moraine ridges or the filling of subglacial valleys, a general thickening can be noticed from north-west towards south-west in the Aylmer-Brownsville area.

3. Structure

The main structural features in pleistocene deposits are caused by both erosional and depositional action of the glaciers and their meltwaters. As the 160 to 325 feet thick pleistocene deposits are a complex of several glacial and interglacial ages and sub-ages, the structure is also complex. Thus it will be discussed separately as the upper and the lower till horizon.

(a) Structural Features in the Upper Till Horizon

Geological profile sections (Figs. 1-7) show that geomorphological forms (Chapter 2) are reflected in the structure of the upper till, showing two ridges with a depression between them.

The Tillsonburg moraine shows about the same difference (up to 70 feet) between the crest of the ridge and the bottom of the Aylmer-Brownsville depression, measured either along the top or the bottom of the upper till horizon. That means that the upper till is not much thicker in the Tillsonburg moraine than in the area of ground moraine in the depression (Figs. 1-7 show that the upper till is 20 to 50 feet thick in the depression and 30 to 60 feet in the Tillsonburg moraine). Thus the Tillsonburg moraine, having a core of older deposits (the lower till) should be considered as a thrust moraine.

An intercalated layer of stratified deposits between two beds of the upper till along the Tillsonburg moraine (Fig. 1) indicates that the ridge was formed both by folding of older deposits, including also the lower bed of the upper till, and then by overriding it and leaving a second relatively thin (2 to 18 feet) cover of the youngest upper till on the top.

In the Norwich moraine topographical relief differences are up to 150 feet between the Aylmer-Brownsville depression and the crest of the moraine. According to well logs the difference in elevation of the bottom of the upper till underneath the moraine and underneath the depression is merely

North Bank of Catfish Creek, in the west part of Aylmer. Lacustrine clay on top of upper till. The spade marks the boundary between them.

Norwich moraine, looking south, Concession X, Lot 6, South Dorchester Township.

60 to 80 feet. The conclusion would be that the Norwich moraine is built up mostly of the upper till, in thickness up to 100 feet (Fig. 3), on the sloping surface of the lower till. Thus it is an accumulation moraine, built during a longer stop of the ice margin along it.

(b) Structural Features in the Lower Till Horizon

The deepest part of the pleistocene deposits, the lower till, including the two main artesian ground-water horizons, reveals another structural feature which is not visible at the surface: a sudden drop of the first artesian ground-water horizon and the corresponding pleistocene deposits along a curved line which extends from about one mile north-west of Aylmer to about one and one-half miles north-east of it and then to a point about one-half mile east of Summers' Corners, the drop amounting to about 100 to 160 feet per mile. (Figs. 1 and 3). This drop is not influenced even by the structure of the Tillsonburg moraine and therefore is older than it.

The next lower artesian water-bearing horizon, coming from the north-east, seems to taper out completely along the above-mentioned line (Figs. 1 and 3.)

The depression below the steep drop is surprisingly poor in groundwater, with several completely dry test-holes and the poor Aylmer Wells Nos. 1 and 2. No strong spring horizons can be found along the Catfish Creek between Aylmer and Lake Erie, or along the lake, though the creek and lake-shore exposures are in places more than 100 feet high. Thus it may be assumed that this steep drop, facing Lake Erie, is a buried interglacial lake cliff, and the lake area below it is filled by later glacial deposits. Poorness in ground water below the "cliff" also indicates a buried, flat, lake-like depression south and south-west of it rather than a buried valley.

Interglacial lacustrine clays at Cleveland and in other places along Lake Erie, similar to the Toronto interglacial clays (A.P. Coleman, 1941, pages 69 - 70), indicate the existence of an interglacial lake in the depression of the present Lake Erie, perhaps during the last interglacial time. Why could not this steep drop near Aylmer be its north shore?

The interglacial clay with wood remains, found 5000 feet west-north-west from the Aylmer Station (M.C. Railway) at a depth of 560 to 585 feet above the sea level (page 12) could be either of a different age or deposited on a creek bottom near the lake.

Trends of ridges and depressions of the second artesian aquifer differ from both the surface forms and the bedrock surface. The general trend of the two strongest buried ridges (from Springfield to Aylmer and north-west of Brownsville) is close to north-north-east - south-south-west, with a depression between them. These "ridges" may mean two moraine trends of a previous glaciation, preserved in the deeper pleistocene structure. The actual buried moraines and the depression between them may be at a greater depth, because the second artesian aquifer may correspond to interglacial or interstadial deposits laid down on top of them.

The third possible ridge-like structural feature, between Glencolin and Corinth, is based only upon two well logs and thus is subject to question.

The first artesian ground-water horizon has a general structure similar to that which is expressed by the topography in the area north-east of the above-mentioned buried interglacial lakeshore; with a higher part along the Norwich moraine and general lowering towards the south and south-east. However, there are some differences: a flat ridge along the central part of the Catfish Creek depression between Aylmer and south-east of Springfield, which could be a buried weak recessional moraine, younger than the Norwich moraine. It branches from the Norwich moraine in the same pattern as do

several recessional moraines between Aylmer and London, that is, with the west end of each youngest moraine more towards the lake.

(c) Relative Age of Structural Features

Without discussing the question to which glacial stage or substage each structural feature may belong, the following sequence could be concluded, beginning with the oldest:

(1) Deepened and widened preglacial valleys in the bedrock surface.

(2) The oldest south-south-west - north-north-east trending ridges (moraines?) and depressions in pleistocene deposits north-east from the buried interglacial lakeshore, including the second artesian aquifer on top of them.

(3) The interglacial lakeshore north, north-east, and east from Aylmer with a deep depression south-east from it, filled with the upper part of the lower till horizon, including the first artesian aquifer, which dips down the steep shore-line.

(4) The ridges and depressions trending west-south-west - east-north-east or south-west - north-east (along the south-east margin of the map) formed by the upper till and the upper part of the lower till, partly including the first artesian aquifer. The oldest of these trends are along the Norwich moraine, the youngest ones along the Tillsonburg moraine.

CHAPTER 4

STRATIGRAPHY OF PLEISTOCENE DEPOSITS AND DESCRIPTIONS OF THEIR DIFFERENT HORIZONS

Most of the creek cuts and artificial exposures of the Aylmer-Brownsville area are shallow, the deepest ones being along the Catfish Creek, just west of Aylmer (about 30 feet deep). Thus the main sources of information regarding pleistocene stratigraphy are the available well logs. In order to interpret them correctly, creek cuts and lakeshore cliffs, as high as 100 feet and more, were examined around the mapped area. They revealed that till, particularly the lower sandy till, is reported as either clay or sand or gravel in different combinations by various well-drillers in their logs. These differing individual interpretations are due to their wash-drilling process, which brings up watery churned material and not the actual till sample. Thus the interpretation depends upon that grain size which was considered by the well-driller as the most characteristic one for the corresponding bed.

Therefore, in drawing stratigraphical profile sections, it is very difficult to correlate well data of different well-drillers correctly. In order to avoid serious errors, only those parts of Figures 1-7 are interpreted in geological terms, where nearby exposures permitted the determination of the petrological composition and geological structure, or else where well data were unmistakable, e.g., reporting pure gravel, water sand, clay with stones, etc.

The pleistocene epoch consisted of four ice ages and three interglacial ages. In our area it is difficult to find deposits of all these seven ages, because every younger ice sheet, overriding the land during the successive ice ages, destroyed and picked up the whole or a part of the unconsolidated deposits of previous ages.

Exposures along the Catfish Creek and well logs reveal at least two different till horizons in the Aylmer area and just south and south-west from it: a clayey or silty upper till and one, or more than one, sandy and gravelly lower till

horizons. No sure interglacial deposits with plant or animal remains are found in exposures of the lacustrine and fluviatile deposits between them.

The only plant remains, covered by two horizons of glacial till, are found in a well 5,000 feet west-north-west from the Aylmer Station (on the M.C.Railway) some years ago. E. Hoover, who drilled the well, reported the following log from his memory:

Depth (feet)		Thickness (feet)
0-180	about	180 - clay (till?)
180-220	about	40 - yellow sand
220-240	about	20 - hardpan (till?)
240-265	about	25 - blue clay with wooden sticks.
deeper		- rock

The elevation of the well is about 825 feet above sea level. Thus the plant remains are found at a depth of 560 to 585 feet above the sea level. As they were reported to have been relatively fresh-looking and not changed into dark lignite they should be of pleistocene age, and probably even of one of the latest interglacials. It is worth mentioning that wood remains of the Toronto interglacial clays are also relatively fresh-looking. Toronto interglacial deposits are considered by the author of this paper, to be of the last, Sangoman, interglacial age because of the lack of proven interglacial deposits on top of them in their type localities and because of similarity in climatic conditions between the Toronto interglacial and the corresponding European last interglacial (Riss-Würm) deposits. Thus it is possible, though not proven, that the interglacial clay with wood remains of the Aylmer Station belongs to the same last interglacial age, and was deposited on alluvial flats of a valley near the last interglacial shore of Lake Erie (page 9).

1. The Lower Till

The relatively sandy and stony till, exposed along the middle and lower part of Catfish Creek below the clayey upper horizon, is called the lower till in this paper.

Its thickness in the exposures is up to 90 feet, including intercalated gravelly deposits. It is not known how deep it extends underneath the creek level and whether it continues down to the bedrock (interlayered by stratified drift).

In many well logs its upper boundary is clearly marked by a change from clay above down to clay with stones or pebbles or even to "sand". It is not possible to determine by materials recorded in well logs another clearly-marked boundary within the lower till.

Therefore the whole glacial complex below the upper till is called the lower till in this paper, though it may consist of horizons of different ice ages. Thus a possible boundary between two horizons in the lower till may be the second artesian aquifer, if it is considered as a layer of stratified drift and not as a combination of lenses of different origin and age enclosed in the lower till. Another dividing boundary in the lower till horizon is the probable interglacial shore north and east from Aylmer (page 8, Figs. 1 and 3).

Thus, if both the second artesian aquifer and the buried interglacial shoreline are assumed correctly to be surfaces of unconformity, marking the top of some deeper and older part of the lower till, the following subdivisions should exist in the lower till horizon.

(a) The older subhorizon, including all glacial deposits underneath the second artesian aquifer and cut by the interglacial lakeshore,

(b) The younger subhorizon, between the second artesian aquifer and the bottom of the upper till, including the first artesian aquifer.

The second artesian aquifer (gravel, sand, etc.) could be considered as a separate interglacial or interstadial bed, or it could be included in the older subhorizon because it is connected with lenses of aquifer on the older subhorizon, e.g., west of Glencolin. The gravel bed, just above the bedrock,

which is reported by several well logs (e.g., Fig. 1), may form a separate, the very oldest, pleistocene horizon of the area, but nothing is known about its age relationship to the lower till.

As already mentioned, the oldest subhorizon of the lower till is not exposed either in the Aylmer-Brownsville area or around it. Thus it will not be discussed in detail in this paper.

The best exposures of the younger subhorizon of the lower till are along Catfish Creek, outside of the Aylmer-Brownsville area (Fig. 1), but across the west extension of the structural Aylmer-Brownsville depression. Thus these exposures were studied in detail, and a profile section, which should characterize the upper half of the pleistocene deposits of the Aylmer-Brownsville depression, was constructed (Fig. 8).

The lower till (or more precisely the younger subhorizon of the lower till) of Catfish Creek is very heterogeneous. It consists of at least three till beds with loamy gravel and sand deposits or boulder pavements between them. The gravelly and sandy deposits, intercalated by lenses of water-laid till, may even exceed the typical till in thickness, e.g., at the fifth exposure of the profile 8 (i.e., along the Tillsonburg moraine). Both till and gravelly deposits are intercalated in such a manner that they indicate deposition in a glacial lake along the margin of an oscillating ice sheet.

Striae on boulder pavements and orientation of elongated pebbles were measured in those relatively massive, non-stratified till layers, which did not seem to be reworked by the lake water. These measurements reveal three quite different ice-flow directions.

(1) About east-west or north 70°-80° west,
(2) About north 10° west,
(3) About north 40° east (with another, east-west maximum).

The last one could be regarded as a relict of the main ice flow direction from the north-east, with a partial reorientation parallel to the east-west direction. The ancient north-east direction may be preserved because the drift material became enclosed in the upper rigid part of the ice sheet, due to its melting from the top, and thus it was carried passively on top of the moving basal part of the ice. The north-east orientation was found three feet below the top of the exposure of the lower till.

The east-west direction corresponds to the general flow of the glacier ice <u>along</u> Lake Erie, while the north 10° west direction indicates an active push <u>from</u> Lake Erie. This one could be caused by formation of a local centre of accumulation of ice and snow in the lake, which caused active ice movements towards the surrounding highlands. L.F. Chapman and D.F. Putnam write (1949, page 34), that the centre of accumulation of the Huron lobe was near its nose, that means in Lake Huron, at the stage of Mitchell moraine. The corresponding moraine in the Lake Erie area is assumed to be the Westminster moraine (ibid., page 34). During that time the Aylmer area was still covered by the ice sheet. A change in the location of accumulation centres similar to that assumed for Lake Huron may be expected also in the Lake Erie lobe.

In the Catfish Creek exposures the north 10° west direction is the oldest one, and it is followed by the east-west and north 70°-80° west flow, thus indicating a further change from a flow <u>from</u> the lake to one <u>along</u> the lake, with a slight deviation towards the land on the north side.

Graphically it could be expressed by the following arrows, if north is at the top of the paper:

(1) x Aylmer	(2) x Aylmer	(3) x Aylmer
Lake Erie	Lake Erie	Lake Erie

Abundance of sandy and gravelly lenses intercalated in the youngest part of the lower till horizon are of great importance for the circulation of ground water. They are favourable for the development of irregular lenses of aquifer rather than of an extensive uninterrupted horizon. Dip angles up to 10° are observed in these gravel lenses along exposures

on Catfish Creek, causing also rising or lowering of water-bearing horizons. Thus irregularities along the top of the first artesian horizon (and probably also of the second one) may be caused by these factors (lenses, and undulating or dipping beds). The same explanation accounts for the very irregular sequence of aquifers at Aylmer (Figs. 1 and 3).

2. Interstadial Deposits between the Lower and the Upper Till

The lower and the upper till are separated by a thin layer (some inches to some feet) of silt, sand, loamy gravel and even varved clay and silt. This contact starts to outcrop in the valley of Catfish Creek about 4,000 feet east from Orwell and can be seen west and south-west from there. In some places the contact is represented merely by a boulder pavement, (Photograph 4), or silty lenses along the shearing planes at the bottom of the upper till. The lacustrine deposits indicate that our area was covered by a glacial lake during the retreat of that ice sheet which deposited the youngest subhorizon of the lower till, and before the ice readvanced again and deposited the upper till.

3. The Upper Till

The upper till of the Aylmer-Brownsville area is clayey and silty, compact, and with relatively few stones. Till of the Tillsonburg moraine between Seville and Corinth differs from that of the remaining area, being heavier and having so few stones and pebbles that it resembles heavy lacustrine clay. It is found that this very clayey till is underlain by varved clay (Fig. 12): when the Tillsonburg moraine was formed by readvance of the Lake Erie ice lobe, lacustrine clay deposits were overridden and partly picked up by the ice, thus causing an increase of clay in the drift.

The thickness of the upper till varies from 20 to 60 feet in the Aylmer-Brownsville depression and the Tillsonburg moraine, and up to 100 feet along the Norwich moraine.

No extensive lenses of gravel or sand are found in the upper till, except those of the Tillsonburg moraine, because the Tillsonburg moraine consists of two layers of the upper till, intercalated by lacustrine and glaciofluviatile deposits. The first, lower layer was deposited during the retreat of the ice from the area. Stratified, mostly lacustrine, deposits were laid on top of it and then overridden again by that readvance of the ice which formed the Tillsonburg moraine (see the north-east part of Figs. 1 and 12). The younger till layer of the Tillsonburg moraine is thinner than the older layer of the same upper till horizon.

As the upper till is relatively massive and impermeable, no ground-water in large quantity is found in it. Even the silty or sandy deposits between the two layers of the upper till in the Tillsonburg moraine are not very rich in water, though some of the springs along this moraine may derive from this layer and supply sufficient water for farm use.

More important is the fact that the upper till seals the deeper aquifers, thus causing the development of artesian waters in the Aylmer-Brownsville area.

Measurements of the long axes of pebbles in the upper till and striae on the boulder pavements below the upper till or along shearing planes at its bottom show the following directions of the ice flow: north 20°-90° west, mostly north 20°-60° west. Minor folds along the basis of the upper till or in the interstadial deposits below it (found in the exposures of Catfish Creek west of Aylmer) are formed across this direction, with their axes trending north 10°-50° east. Folds are overturned in a north-west direction, which indicates that the movement of the ice, which deposited the upper till, was from the south-east, that is from Lake Erie. Both the Norwich and Tillsonburg moraines, formed along the margin of this ice lobe, have about the same trend as the above-mentioned minor folds.

4. Late-Glacial and Recent Deposits on Top of Till

After the final retreat of the Wisconsin ice sheet from the mapped area it was covered by glacial lakes and spillways, and later, after becoming dry land, the surface deposits were reworked by wind, running water and frost action, and some recent deposits, mostly in valleys, were added.

Thus several, usually thin, layers of silt, clay, sand and organic remains can be found on top of the till (see the stratigraphical chart on page 35A).

All these deposits will be discussed in sequence of their age, starting with the oldest ones.

(a) Lake Maumee Silt and Clay

During and after the retreat of the ice sheet the whole map area was covered by the oldest known of the late glacial lakes in our area - Lake Maumee.

Among its deposits the most important is silt, (Photographs 8-9), mostly covering the Norwich moraine and the north side of the Aylmer-Brownsville depression; clay without varving (Photographs 6-7) and varved clay in the depression down to the Tillsonburg moraine. Varved clay is partly overriden by the uppermost till sheet of this moraine. These deposits are in thickness up to six feet in the mapped area, increasing in a south-west direction.

The bottom part of both types of lacustrine deposits contains pebbles, which can best be seen in the bottom part of the varved clays in the exposures west of Aylmer (Figs. 8 and 9).

In some places the lacustrine clay (without varving) is merely a reworked till surface, without showing a sharp boundary between till and clay on its top, e.g., just north of Aylmer. The reworked part (up to one to two feet) is merely softer and more porous, and breaks in smaller bits when dry. Generally, lacustrine deposits are less resistant to erosion than till in our area, and thus step-like profiles develop along creeks

due to faster erosion of the softer lacustrine deposits (Photograph 7).

Varved clay and silt, or clay only, is found in the central part of the Aylmer-Brownsville depression. Varving is less marked towards the Norwich moraine, and clay becomes siltier and sandier in the same direction, without a sharp boundary between silt and clay areas. As varved clay is covered by later silt and sand deposits in many places the actual area of Lake Maumee clay is larger than that shown on Map 1.*

However, some smaller clay areas along Catfish Creek and south of it are younger and may belong to the Lake Whittlesey stage (pages 27-30).

A typical profile section of varved clays is exposed in the clay pits of a brick and tile yard north of Brownsville Station. About six feet of varved clay, more silty towards the bottom and with irregular thickness of varves, can be seen there. It is covered by gravelly sand, one-half to one foot thick, with pockets reaching into the top of the clay down to a depth of two feet. This gravelly sand belongs to the later, younger, spillway deposits of Lake Arkona time. According to the information supplied by the owner of the pit, varved clay varies in a lateral direction, being more silty in some places. Such variation indicates irregularities during the deposition, caused perhaps by currents.

Profiles of varved clay and silt were studied at several places and the varves measured and counted. In no place was the number of varves higher than twelve. A comparison of all five measured profiles gives the maximum number of thirteen varves. That means that varved clays were deposited in Lake Maumee between the Norwich and Tillsonburg moraines in

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* Varved clay is found, either exposed at the earth's surface or covered by younger deposits, in the area from one mile north-east of Brownsville Station down to the south-west end of the mapped area and beyond its west boundary.

a period of thirteen years. The lacustrine clay, which is found just underneath the varved clay, shows an irregular lamination with possible varves of great thickness and lenses of silt and pebbles of both gray and reddish clay and harder material. A good example of such deposits is the exposure (b) in profile 8. The thickness of this irregularly stratified clay is the same as that of the varved clay, or even a little greater. The coarse structure, however, indicates a faster deposition, probably twice as fast as that of the varved clay. Thus the entire time period, when the lacustrine clays were deposited in Lake Maumee, could be calculated as about twenty years.

Thus it is no wonder that no well-marked shorelines with accumulations of beach deposits were formed during the Lake Maumee time in our area. (See discussions on shorelines on pages 21-23.)

The Norwich moraine and its slope down to the Aylmer-Brownsville depression is covered by a thin veneer of silt (Photographs 8 and 9). Many profile sections, particularly along the north side of the Aylmer-Brownsville depression, show two horizons of silt, intercalated by a sandy layer. (Clay may occur instead of silt in the lower layer.) Let us note two examples:

(1) 3,500 feet south of the Springfield main crossing (No. 768):
3 feet lacustrine silt (Lake Whittlesey?)
½ foot silty sand and pebbles (Lake Arkona?)
½ foot silt (Lake Maumee?)
½ foot and more - till

(2) One and one-half miles east of the Springfield main road crossing (No. 728):
2½ feet sandy and clayey silt with some pebbles at the bottom (Lake Whittlesey?)
1½ feet sand (Lake Arkona?)
2 inches heavy lacustrine clay (Lake Maumee?)
½ foot and more - till

It seems that only the lower silt or clay belongs to the Lake Maumee stage, while sand and the top silt layer are younger, of the Lake Arkona and Lake Whittlesey age, because the exposures are below these shorelines.

Lake Whittlesey plain, north-west of Aylmer, Concession VIII, Lot 4, Malahide Township.

Lake Arkona sand plain with low dunes, Concession V, Lot 4, Malahide Township.

Above the Lake Arkona and the Lake Whittlesey shorelines there is only one silt layer. As it is without apparent stratification and covers even shorelines along the slopes of the Norwich moraine, another possibility had to be tested: that of its aeolian origin. Several exposures of silt, both in the mapped area and at Sparta, Ontario, were studied to find out whether these silt deposits are of aeolian or lacustrine origin. Involutions of till, even covering silt (Fig. 19 and Photo. 8) and rounded pebbles in silt, indicate water deposition rather than wind deposits on dry land.

Silt found along shorelines and covering them is less uniform in grain size, thus indicating redeposition by soil flowage downslope. Soil flowage and soil erosion along the slopes of the Norwich moraine have in many places removed silt from the steepest slopes and redeposited it at lower levels.

There are two locations in the Norwich moraine, where small mounds of lacustrine clay are found, surrounded by till at a lower elevation:

(1) Half a mile south of Lyons, at the elevation of 848 feet.

(2) One and one-half miles north of Brownsville, at the elevation of 923 feet (No. 1003).

These mounds of lacustrine clay in the area of silt may have been laid down in local ponds on the melting surface of ice or between blocks of stagnant ice on the top of the moraine, and may thus be classified as crevasse fillings. The first location, south of Lyons, has several elongated mounds, made of lacustrine clays and arranged in a pattern of low crevasse fillings.

(b) <u>Shoreline Levels of Lake Maumee</u>

Lake Maumee, though it covered the Aylmer-Brownsville area for a relatively short time, has left at least six shorelines along the slope of the Norwich moraine (Fig. 3, shorelines V to IX; and Photograph 13) and some weak remnants

of the lowest one (Va and V) along the very top of the Tillsonburg moraine. These shorelines are tilted by a stronger rise of land in the north, thus rising in a north-east direction. That indicates a strong rise of land in the north-east, even during the changes in Lake Maumee levels.

In order to show the relative difference between the shorelines in actual measurements, elevations of different Lake Maumee shores along the boundary road between the Townships of South Dorchester and Dereham (on the south slope of the Norwich moraine) are given in the following table:

X	- a relatively strong shoreline at	907.4	feet
IX	- a weak shoreline, much stronger further west, at	895	feet
VIII	- a strong shoreline at	882	feet
VII	- a weak shoreline at	863	feet
VI	- a strong shoreline at	847-850	feet
V	- a weak shoreline heavily covered by silt at	831	feet

More washed-out top of till or thin deposits of sand or gravel are found along these shorelines, due to the short time of their formation. Most of them are covered by silt now, partly due to soil erosion and the creeping of silt downslope. The thickest cover of silt is on the shoreline V, and it is also the weakest one. It seems that this shoreline has been submerged after its formation, washed out and then covered by silt. The strongest one is No. VI, and along at least one-half of the length of the Norwich moraine it marks the boundary between thicker silt deposits (1 to 4 feet) below it and a relatively thin silt (0 to 2 feet) above it.

Thus the conclusion could be drawn, that, after the lowest shoreline of Lake Maumee (V) was formed, the lake level rose to the next higher level (VI), which is 18 to 20 feet above the level V, and the lower shoreline V became covered by lacustrine deposits.

Comparison with Lake Maumee beaches at other places in the Great Lakes area (F. Leveret and F.B. Taylor, 1915, pages 322, 397) indicates that:

(1) The higher levels (VII-X) of the Aylmer-Brownsville area belong to the end of the first stage of Lake Maumee (Lake Maumee 1).

(2) The lowest level (V) belongs to the second stage (Lake Maumee II).

(3) The level VI belongs to the third stage (Lake Maumee III).

As beach levels of the second stage, though fragmentary, are found along the Tillsonburg moraine south and south-west of Summers' Corners, the ice must already have retreated from it.

(c) <u>Deltaic Shoreline and Spillway Deposits of the Lake Arkona Time</u>

As already mentioned in the preceding chapter, the clay and silt deposits of Lake Maumee are covered by sand and gravel below the highest waterline of Lake Arkona time (Map 1). The Aylmer-Brownsville depression was occupied by a wide spillway at that time, carrying a strong meltwater stream, which discharged into Lake Arkona at Aylmer. Three shoreline and spillway bank levels, probably belonging to the Lake Arkona time, are observed along the Aylmer-Brownsville depression (I-III, Map 1; and Photographs 19-23). They have a steeper tilting than the shorelines of the Lake Maumee or Lake Whittlesey, particularly in the north-east part of the area, because, being stream banks (spillway banks) there, they were above the actual level of Lake Arkona. In some places Lake Arkona shorelines are covered by later sand deposits, which may belong to the Lake Warren time (pages 30-31).

In the mouths of smaller creeks, which discharged in this wide spillway, sandy loam or even loamy gravel was deposited, e.g., sandy loam just east of the airport or 1½ miles south-east of Springfield, and gravel 2½ miles east of Springfield and 1-1/3 miles north of Aylmer.

As these gravel deposits have some economic value, characteristic profile sections and brief descriptions of them will be given:

(1) Deltaic gravel deposits at the mouth of a drainage depression about one and one-third miles north of Aylmer, on both sides of Highway No. 73 along the road between Concessions VIII and IX, along or just above the highest Lake Arkona shoreline. Gravel deposits are covered by a thin veneer of Lake Whittlesey lacustrine stratified silt and sand or they are partly eroded (in depressions) by the same creek which was in the drainage depression during the Lake Whittlesey time or later. A typical exposure is in a road-side ditch 1,800 feet east from Highway 73 (No. 58):

4 feet stratified sand (Lake Whittlesey)
½ foot coarse gravel (Lake Arkona beach)
more than ½ foot - till

A gravelly mound, about six feet high (erosional remnant of the deltaic deposits) about a thousand feet north-west from the intersection of Highways No. 3 and No. 73 has the following profile:

1 foot - sand with pebbles (Lake Whittlesey)
more than 2½ feet - coarse sand and stones, very hard to dig (Lake Arkona)

Two abandoned gravel pits are on this delta (Map 1)

(2) Deltaic gravel deposits at the mouth of a creek about two and one-half miles east of Springfield (Map 1) along one of the lower shorelines of Lake Arkona (No. 805). They appear in a fan-like terrace just below the shoreline, with an old gravel pit, where gravel has been taken for the Springfield school. Maximal thickness of gravel is more than nine feet.

The main bed of the spillway is filled mostly with sand, with increasing thickness in the south-west direction (up to 15-25 feet). This sand has a slight admixture of silt and pebbles.

Larger amounts of gravel can be found in the upper part of the spillway, along its axis, between Glencolin and Brownsville Station (Map 1). The gravel is up to eight feet thick, covered by a couple of feet of sand and underlain by sand in some places. It is coarser at the north-east end

of the strip, because the stream, which deposited it, came from the north-east. The thickness of the gravel and its coarseness are shown by the exposure in gravel pits along a north-east - south-west line. The first and largest gravel pit, Watter's (Photograph 11), near the north-east end of the gravel area, is on Concession XI, Lot 24, Dereham Township, just north of the road between Concessions XI and XII. Its profile section shows:

2-3 feet sand
about 8 feet coarse gravel and water

The next one (abandoned) is about 3,000 feet farther south with:

2 feet sand with pebbles
3-4 feet gravel and gravelly sand
2 feet stratified sand

About two miles farther south-west there are three abandoned gravel pits, two miles north-east of Glencolin, on Concession IX, Lots 27 and 28, Malahide Township, with

2 feet sand
6 feet fine gravel, interbedded by coarse sand.

Farther south-west, gravel or gravelly sand is reported in only one well (No. 136) just south-west of the Glencolin corner, having the following profile:

4 feet sand
8 feet gravel
deeper clay

It too may be a shoreline deposit.

Spillway banks, along the three probable spillway levels of the Lake Arkona time, (shorelines I-III) show mostly accumulations of sand, particularly along banks of the lower stages. Along these sand banks, thin layers of black humous sand and loam are found, e.g.:

a Concession VIII, Lot 12, Malahide Township, 4,400 feet north-east from the intersection of Highways No. 73 and No. 3, on the north side of the spillway below the bank (No. 446):

½ foot - lacustrine clay with some pebbles (Lake Whittlesey?)
¼ foot - dark gray humous loam with water, soft (Lake Arkona?)
1 foot - heavy clay (Lake Maumee?)
½ foot - till

b Concession X, Lot 26, Malahide Township, 1-2/3 miles south-east from Springfield, on the north shore of the spillway (No. 734):

3 feet - sand (spillway levee))
½ foot - black humous sand) Lake Arkona
1½ foot - silty clay, more silty at the top (Lake Maumee?)

c Concession VII, Lot 19, Malahide Township, 2,000 feet west-north-west from Summers' Corners, south side of the spillway on the slope (No. 1150):

2 feet - humous sand)
1 foot - soft sand) Lake Arkona)
½ foot - lacustrine clay, heavy (Lake Maumee)
½ foot - till

These loamy or sandy layers with organic remains may indicate a relative abundance of vegetation during the Lake Arkona time.

Large gravel deposits along the shoreline are found in the south-west corner of the mapped area (Concession V, Lot 7, Malahide Township), where a gravel spit was formed at the west end of a peninsula (a part of the ridge of the Tillsonburg moraine). Large gravel pits are operated in this spit, though the gravel is not very thick. A typical exposure is in the north-west pit:

4-6 feet dune sand
6-12 feet fine gravel with pebbles
(bottom of the pit)
1 foot coarse sand
more than 1 foot fine sand

G. Nevill's well, just south from the gravel pit (Concession V, Lot 7, Malahide Township) has the following log:

3 feet soil
10 feet gravel
19 feet sand

The greatest part of this spit has been exploited. Some smaller gravel deposits are found along the shore of Lake Arkona or the banks of the corresponding spillway in other places, but without great practical importance.

(d) Lake Whittlesey Deposits

After the Lake Arkona time the level of the glacial lake rose again, and a wider area was covered by it during the Lake Whittlesey stage than during the Lake Arkona time (Map 1). Only the very north-east part of the Aylmer-Brownsville depression was wider during the Lake Arkona time, because the large amount of meltwater, pouring along the spillway from the north-east, was at a higher level there than the actual Lake Arkona.

During the Lake Whittlesey time even the greater part of the Tillsonburg moraine was submerged, and only the highest parts of it were above the lake level, like islands. This row of islands separated the Aylmer-Brownsville depression from the open lake (Photographs 15 and 16). No thick lacustrine deposits of this time are encountered in the depression, perhaps due to lack of a strong north-east stream (which existed during the Arkona time), separation from the open lake, and the shallowness of the water. Depth of water in the depression may have been 35 to 60 feet in its deepest part.

The upper silt and loam cover along the north-west side of the depression was laid down during this time, due to the existence of smaller creeks along the Norwich moraine (see the descriptions of exposures listed on pages 20-26).

Clay and silt just below the Lake Whittlesey shoreline is found more along the Tillsonburg moraine, and more towards the open lake, e.g., Concession X, Lots 31 and 32, Malahide Township, about three miles south-east from Springfield (No. 695):

1 foot	lacustrine silty clay, plastic	Lake Whittlesey
1 foot	lacustrine silt	
1 foot	fine sand (Lake Arkona?)	
1½ foot	heavy lacustrine clay with concretions at the bottom (Lake Maumee?)	

or 1,600 feet north of this auger hole, at a lower level (No. 693):

1 foot silt (Lake Whittlesey?)
½ foot silty sand (Lake Arkona?)
1 foot heavy lacustrine clay (Lake Maumee?)

Farther south-west the Lake Whittlesey clay is covered by sand again, e.g., north and west of Summers' Corners, either during the lowering of the Lake Whittlesey level or later during the meandering of creeks, particularly during the Lake Warren time, and partly due to wind action. In some places it is difficult to tell whether these clay beds between two sand layers are of Lake Maumee or Lake Whittlesey age.

No extensive lacustrine deposits on top of the Lake Arkona deltaic sands are found in the central part of the Aylmer-Brownsville depression. However, there are some smaller clay deposits on top of the Lake Arkona deltaic sands, e.g., just north-east and north from the intersection of the Concessions VIII-IX road and Lots 25-26 road, Malahide Township. The profile section No. 596 north-east from the corner is as follows:

½ foot-2 feet lacustrine clayey silt and silty clay, becoming more clayey with increase of thickness (Lake Whittlesey)
2 feet - sand (Lake Arkona).

It may be that a great part of the thin deposits of Lake Whittlesey time along the central part of the Aylmer-Brownsville area was eroded by meandering creeks.

On the extreme south-west island along the Tillsonburg moraine, south-west of Summers' Corners, sand covers the ridge above and along the Lake Whittlesey shoreline, with accumulation of gravel at Summers' Corners along Highway No. 3 (beach deposits below the waterline, probably combined with Lake Arkona beach deposits).

These sand deposits are mostly without pebbles and may be regarded as beach sands and windblown sands above the water level, deposited during the Lake Whittlesey time or even beginning with the Lake Maumee time and partly redeposited later, even after the Lake Whittlesey stage.

The above-mentioned gravel deposits at Summers' Corners are only a few feet thick, and they have been exploited in a shallow gravel pit just west of Summers' Corners. The pit

is no longer used. The following material is exposed in it (No. 391):

2 feet sand
4 feet fine gravel and pebbles.

Smaller gravel deposits are found along the Lake Whittlesey shoreline in many places (Map 1).

Two or even three Lake Whittlesey shorelines (Photographs 17 and 18) can be observed along the south side of the depression, and one along the north side. Their tilting north-east is similar to that of the lower three shorelines of Lake Maumee.

A wide mouth of a drainage depression existed north-east of Springfield. Thus no sharp shorelines of either Lake Whittlesey or Lake Arkona time can be found there. However, gravelly sand is found at the water level of that time at several places, but very often it is covered by silt or silty sand, e.g., about 6,000 feet east-north-east from Springfield, on the Lot 3/4 road, Concession XII, South Dorchester Township (No. 849):

$\frac{1}{2}$ foot - silt or silty soil) (Lake Whittlesey)
$1\frac{1}{2}$-2 feet - sand and gravel)
$\frac{1}{2}$ foot - silt and pebbles (Lake Maumee)
$\frac{1}{2}$ foot - till

The silt on the top of sand and gravel may have been deposited by the creek during floods, because the creek depression is very wide.

Farther north-east, both Lake Whittlesey and Lake Arkona higher shorelines are running at the same elevation, at the road between Concessions XI and XII, South Dorchester Township, in Lots 1 and 2. Sandy and gravelly deposits also with silty cover are found there, e.g., (No. 882):

$\frac{1}{2}$ foot - sandy silt with pebbles)(Lake Arkona and
$1\frac{1}{2}$ foot - sandy gravel) Lake Whittlesey?)
1 foot - yellow stratified silt (Lake Maumee?)

Farther east the Lake Whittlesey shoreline is below the Lake Arkona spillway bank.

In the area between Seville and Corinth, just south-east from its south-east shoreline along the Tillsonburg moraine, no deposits of Lake Whittlesey time are found. The top

of the till is exposed at the surface there, in some places with scattered stones, washed out of the very clayey till. That may be due to wave action along the shore of the open lake.

(e) Younger Deposits than Lake Whittlesey

After the lowering of the lake level of Lake Whittlesey our area became land. The surface deposits were exposed to erosional processes and were partly removed, partly redeposited.

As the highest level of Lake Warren (one of the next relatively long stages after Lake Whittlesey) was only about 15 to 30 feet below the Lake Arkona beaches in our area (F. Leverett and F.B. Taylor, 1915, page 397, and plate 18), the south-west end of the Aylmer-Brownsville depression with its elevation about 730 feet above sea level may have been near the highest level of Lake Warren. That means that the upper part of the sand deposits, e.g., those covering the Lake Whittlesey clay and silt in the profile shown in Fig. 1, in the area south-west from Glencolin, may be deltaic deposits of the Lake Warren time. The widely branching pattern of valley-like depressions, particularly in the area south of Aylmer, supports this assumption, because it is characteristic for deltaic regions. Creeks of the Lake Warren time probably used the same depressions in higher areas as during the previous ages. Thus a combination of creek banks and terraces in the highest parts of the depression should be expected, with the Lake Warren drainage pattern following particularly the Lake Arkona drainage pattern, which was the lowest one from the previous time.

The dry and warm boreal climate probably started around the Lake Warren time or just after it. It was favourable for the formation of dunes both along the drainage pattern of the Lake Warren time and on sand deposits of higher levels. Thus the low dunes (up to 10-30 feet high), which can be seen along the Lake Arkona waterlines along the south boundary of the Aylmer-Brownsville depression, were not formed during the

Lake Arkona time, but later, during or after Lake Warren time. The flat deltaic deposits of both Lake Warren and Lake Arkona time, where exposed at the surface, were reworked in slightly undulating landscape, e.g., south of Aylmer. Sand found in dunes is more evenly grained than in typical deltaic deposits.

Later, when the low drainage depressions became covered by thick vegetation due to lowering of the lake levels, muck and peat started to accumulate there. Terraces in creek valleys became covered by silt, sand, loam, and organic remains, particularly during flood time, thus accumulating 1 to 6 feet of loamy alluvial material ("bottomland"), particularly along Catfish Creek and Bradley Creek.

Freshwater lime may have been deposited in wet places where springs with calcareous water discharged. Only one small deposit (some tens of feet wide) was found in the mapped area, about 4,200 feet east-south-east from Glencolin (Concession VIII, north half of Lot 24, Malahide Township, 1,900 feet south of the Concessions VIII-IX road). It showed the following profile in its central part (No. 562):

$1 - 1\frac{1}{2}$ feet - peat
$\frac{1}{2}$ foot - white and soft freshwater lime or "marl"
1 foot - sand

Soil erosion along slopes, particularly in moraines, caused exposure of till in depressions and accumulation of silt at a lower elevation, often on the top of the flat beach terraces.

CHAPTER 5

GEOLOGICAL HISTORY OF THE AYLMER-BROWNSVILLE AREA DURING THE LATE WISCONSIN TIME AND AFTER THE RETREAT OF WISCONSIN ICE

The recent studies of stratigraphy of the Wisconsin glacial age reveal that during the Tazewell-Cary interstadial time many areas in the United States were uncovered by ice due to a prolonged retreat of the ice-sheet (R.F. Flint, 1950, pages 32-33; G.M. Richmond, 1950, page 69). Thus, based upon the stratigraphic evidences discussed in the previous chapter, the upper half of the lower till is assumed to be the Tazewell and Pre-Tazewell deposit.

During the Tazewell-Cary interstadial the ice-sheet retreated from our area in an east direction, and lacustrine and fluviatile deposits, found between the lower and the upper till, were deposited during this time. This interstadial probably corresponds to the "first stage of retreat", when "the ice fronts withdrew an unknown distance to uncover a large area of the upland of southwestern Ontario" (L.F.Chapman and D.F. Putnam, 1949, page 29).

During the beginning of the Cary substage the ice re-advanced again from the south-east, and the Lake Erie lobe, having picked up lacustrine clay from the lake bottom which had formed in the Lake Erie depression, spread the clayey upper till over our area and farther north-west up to London.

Then the ice retreated towards the Lake Erie basin again, forming recessional moraines along lines where the ice margin either stopped or oscillated for a while.

Thus the retreating ice stopped along the north-west and north margin of the Aylmer-Brownsville area for some time, accumulating the Norwich moraine there.

Then it retreated from our area completely in a south-east direction due to fast melting from the top of the ice-sheet, and our area became covered by the glacial Lake Maumee.

After about twenty years the Lake Erie ice lobe re-advanced up to the south-east boundary of our area, forming the Tillsonburg moraine; folding the pre-existing deposits and overriding them down to the north-west foot of the moraine. Then it retreated towards the south-east again, for the last time. While the Tillsonburg moraine was being formed, the Lake Maumee level, though fluctuating, reached up to the crest of the newly formed moraine or even above it. Silt was deposited in Lake Maumee along the north-west side of the mapped area, up to the top of the Norwich moraine. Varved clay and silt were laid down farther south-east, and a part of these deposits was overridden by the re-advancing ice in the area of the Tillsonburg moraine and south-east from it.

The relatively smooth surface of both the Norwich and Tillsonburg moraines and lacustrine deposits on their top indicate their formation below water. That means that the ice margin was in the lake, forming its south-east shore at that time. The greatest depth of the glacial Lake Maumee at its highest stage in the Aylmer-Brownsville depression may have been about 140-150 feet at its lower south-west end.

Because of the rapid changes of the lake level (at least six levels in our area) and the short time of their existence, no beach deposits worth mentioning are left along the Lake Maumee shores.

The Lake Arkona time follows with a lowering of the lake level, so that only the south-west part of the Aylmer-Brownsville depression was occupied by the lake. A strong meltwater stream discharged into this embayment between the Tillsonburg and Norwich moraines, coming from the north-east. It deposited sand and gravel along the bottom of the Aylmer-Brownsville depression and along at least three shorelines and spillway banks of this time. A strong gravel spit was formed at the end of the peninsula of the Tillsonburg moraine in the south-west corner of the mapped area.

Organic remains along shores and banks of Lake Arkona, and of the spillway discharging into it, probably belong to the Cary-Mankato interstadial, corresponding to the Two Creeks interstadial in north-east Wisconsin, which, according to the report presented by R.F. Flint at the 1950 annual meeting of the Geological Society of America, in Washington on November 18, 1950, was about 11,400 years ago.

At the beginning of the next (Mankato) substage, the lake level rose again, and this stage of glacial lakes is called Lake Whittlesey. Its shorelines are higher than those of the previous time in our area with the exception of the spillway banks around Brownsville and Delmer. Lake waters covered the Aylmer-Brownsville depression and the greater part of the Tillsonburg moraine. The highest parts of that moraine formed a row of islands between the open lake and the protected Aylmer-Brownsville depression. The upper lacustrine silt along the north-west side of the depression was deposited during this time below the Lake Whittlesey shoreline; and there were some sandy and gravelly deposits along the shoreline. Interrupted deposits of silty clay of this time, laid down on the deltaic sands of Lake Arkona, are found farther to the south-east, towards the Tillsonburg moraine. As a result of wave action along the open lake, the south-east side of this moraine between Seville and Corinth is without any lacustrine deposits overlying till.

After the Lake Whittlesey time the lake levels lowered for about 75 feet during the Lake Wayne time, and the entire mapped area became land.

Soon the level of glacial lakes rose again, during the Lake Warren time, reaching a level about 15 to 30 feet below the level of Lake Arkona. The lower south-west part of the Aylmer-Brownsville depression was close to this level and received a cover of deltaic sands, carried by the creeks from the north-east and north, on top of Lake Whittlesey

clay deposits. A braided drainage pattern developed in this low area south and south-east from Aylmer.

During the subsequent lowering of the lakes down to the present level, terraces were cut along creeks and alluvial deposits were laid down on them, forming the bottom-land. The exposed sandy deltaic deposits of different ages were reworked by wind in dune ridges along the ancient shore-lines and in an undulating relief in plains.

The poorly drained depressions of the braided drainage pattern of Lake Arkona and Lake Warren gradually became filled with muck and decomposed peat.

Slopes of end moraines, exposed to soil erosion, became partly stripped of the cover of the lacustrine silt, and it was carried down to lower levels and deposited for the most part on flat terraces or in the lowest depressions. Along the slopes, the highest parts still have their original cover, while the depressions expose the underlying till.

TABLE I

STRATIGRAPHICAL TABLE OF PLEISTOCENE DEPOSITS
IN THE AYLMER-BROWNSVILLE AREA

Recent		4 - Post-Lake Warren	Formation of dunes, lower terraces in creek valleys, bottomlands; accumulation of muck, peat and fresh-water lime in depressions, soil erosion
Wisconsin Ice Age	Mankato Substage	3 - Lake Warren	Deltaic sand deposits in the south-west part of the Aylmer-Brownsville depression
		2 - Lake Wayne?	
		1 - Lake Whittlesey	Raising of lake level; the upper silt and clay deposits, sandy and gravelly shorelines
	Two Creeks Interstadial = Lake Arkona		Lowering of lake level; sandy and gravelly deltaic and spillway deposits; sand and gravel along shorelines and spillway banks, with organic remains
	Cary Substage = Lake Maumee		5 - Lake Maumee III with rising of lake level - final retreat of the Lake Erie ice lobe
			4 - Lake Maumee II with lowering of lake level, re-advance of ice and formation of the Tillsonburg moraine, deposits of the upper part of the upper till in this moraine
			3 - End of Lake Maumee I with changing lake levels, probably lowering of them; retreat of the ice from the Aylmer-Brownsville area, deposition of the upper till with varved clay and silt on top of it
			2 - Retreat of the Lake Erie ice lobe down to the Norwich moraine, and formation of the moraine; the Aylmer-Brownsville area still covered by ice
			1 - Re-advance of the Lake Erie ice lobe and covering of the entire area
	Tazewell-Cary Interstadial		Ice retreat, deposition of lacustrine silt and fluviatile sand and gravel (found between the upper and lower till)
	Tazewell and Iowan Substages		Deposition of the younger subhorizon of the lower till; ice margin surrounded by lake
Sangoman Interglacial			The interglacial Lake Erie with a shoreline at Aylmer; (the alluvial clay deposits with wood remains, at the Aylmer Station, probably of this age)
Pre-Wisconsin Ice Ages and Interglacials			The older horizon of the lower till with interstadial and possible interglacial stratified deposits

CHAPTER 6

GROUND-WATER HORIZONS

1. Introduction

Water which fills all openings in rocks below the earth's surface is called ground water. If these openings, particularly pore spaces, are sufficiently wide, water can flow continuously, though slowly, through them from higher to lower elevations. The top of such a wide water body underground is called the water table. Where it reaches the earth's surface, springs may develop.

The main source of ground water is precipitation of rain and snow. The amount of yearly precipitation in our area is about 35 inches. A part of the rainwater and water from melting snow runs off along the earth's surface towards creeks and is carried by them down to the lake, a part evaporates, and only the remaining part percolates into the ground. W.C. Curd (1923) calculates that run-off in the London, Ontario, area is about 40 per cent of the annual precipitation, evaporation is another 40 per cent, and only 20 per cent percolates into the ground, forming groundwater. J.F. Caley, T.H. Clark and E.B. Owen (1948, page 4) estimate an even lower proportion (10 per cent) for percolation into the ground in York County, Ontario. They show, however, in the same paper, that this quantity is sufficient for recharge of ground water in rural areas.

The intake area for the uppermost, non-artesian ground-water horizon is the local Aylmer-Brownsville area, while the intake for the artesian horizons is mostly the high land in the north and north-east.

As different geological formations are of different permeability, ground water is not evenly distributed, but is concentrated in rocks with a larger amount of pore space. What is more important - it can flow only if these pore spaces are sufficiently large, as it is in the so-called permeable rocks, e.g., gravel, sand, fractured limestone, even sandy till,

and silt. If the rock has pore spaces too small, like heavy clay and till it is practically impermeable.

Thus ground water is separated by these impermeable layers into several horizons. These horizons may have interruptions in their extent in a lateral direction as a result of the thinning-out of beds of pervious material or of a change in the diameter of pore spaces in them. However, they never form narrow ground-water "streams" or "veins" in our area, as is believed by some people.

The uppermost ground-water horizon, lying above an impermeable bed (the upper till) is characterized by a free water table, and is non-artesian.

All other ground-water horizons in our area, filling the entire space between tilted impervious layers, are under hydrostatic pressure. If a well pierces the aquifer, the ground water, being under pressure, rises in the well, either above the earth's surface (flowing artesian well) or to some level below it (non-flowing artesian well). A surface, connecting water levels in all artesian wells, is called the pressure surface or piezometric surface. In our area the piezometric surface of artesian water is mostly below the ground-water table, except in the area with flowing wells south of Springfield, and along the north slope of the Aylmer-Brownsville depression around Brownsville (Fig. 5).

Well logs and geological studies (see the stratigraphy and structure, pages 11 - 31) reveal at least five ground-water horizons in the pleistocene deposits of the Aylmer-Brownsville area, yielding mostly fresh water:

(a) The non-artesian ground water (called surface water by many farmers) in the late glacial and post-glacial deposits (Chapter 4, Section 4).

(b) A local horizon of artesian water in the upper till along the Tillsonburg moraine.

(c) The upper main (first) artesian ground water in the youngest subhorizon of the lower till and in the interstadial deposits between the lower and the upper till (Chapter 4, Sections 1 and 2).

(d) The second artesian ground-water horizon near the top of the theoretical boundary between the older and the younger sub-horizon of the lower till, partly in the older subhorizon (Chapter 4, Section 1).

(e) The artesian ground water at the bottom of the pleistocene deposits and in the upper part of the bedrock; this last horizon has more sulphur water than the first four, because it is on the boundary with sulphur water underneath it.

Most of the artesian horizons in pleistocene deposits of our area, having about the same piezometric surface, are interconnected, probably in the north and even outside of our area. Thus the two upper artesian ground-water horizons may be connected north of Springfield, where a structural anticline of the second artesian aquifer is cut by the subsequent glacial advance, and thus connected with the first aquifer in the overlying deposits.

The piezometric surface of that artesian water which comes from the top of the bedrock very often differs from that of overlying horizons, indicating a poor or even no connection between them.

It is to be noted that most conclusions regarding ground-water conditions in the Aylmer-Brownsville area are based upon information from farmers, with a lesser amount received from the Town of Aylmer, International Water Supply Limited, London, Ontario, several gas companies, the well-driller Mr. L. McBeth, the R.C.A.F. airport at Springfield, etc. The depth of dug wells and their water level was measured, if possible. Unfortunately many farmers did not remember all the data regarding their wells; depth of water or well was found in several cases to be exaggerated. Some drillers of gas wells confessed that they were not much interested in the pleistocene deposits, as they were required to give a detailed report only

on the bedrock; thus their data on pleistocene strata were not always accurate. In some deep wells it seems that the drillers penetrated the upper ground-water horizons without recording them.

All these facts and others made necessary a very careful evaluation of the well data, and some records had to be discarded.

The total number of wells reported in the summary of well data (Table II) should be greater than 511 by at least 10 per cent because some farmers were not at home when their farms were visited, or they did not report their abandoned or dry wells or wells which were out in the pasture.

2. The Non-Artesian Ground Water

The non-artesian ground water is confined mostly to the shallow pervious deltaic and lacustrine deposits on top of the upper till, particularly in the Aylmer-Brownsville depression. Thus most wells receiving water from this horizon are located in this depression, their majority in its southwest part where the sandy deposits are thickest.

The thickness of the surface aquifer varies from about 1 to 30 feet. The depth of wells which depend upon this ground-water horizon is 6 to 30 feet. About 40 per cent of all recorded wells and springs of the Aylmer-Brownsville area receive their water from this non-artesian ground-water horizon. As the wells are shallow, more than half of them are equipped with hand pumps.

Where the aquifer is thin, wells are dug into till, and water flows or percolates into them from the surface aquifer, particularly during rainy seasons or when snow melts. In dry seasons these wells lose most of their water and may become completely dry. Thus in the area about two miles north of Aylmer the water level fluctuates from 4 - 7 feet below the earth's surface down to about 22-30 feet, completely drying out in dry summers or autumns, as in 1949.

Most of the non-permanent wells, which constitute 5 per cent or more of the total number of wells, belong to this group.

In the central part of the Aylmer-Brownsville depression, wells which use this ground-water horizon, are dug or merely driven into the aquifer or down to the till but not into it. They yield sufficient water for farm use, particularly where the aquifer is coarse sand or gravel. The driven wells ("sandpoints") are not satisfactory in the extreme southwest part of the depression, e.g., Concession V, Lot 5, Malahide Township, because the sand becomes too fine-grained there and enters the openings of the screens.

Water of this horizon is mostly hard. It may become contaminated bacteriologically by surface seepage from barns and cesspools or simple seepage of surface water.

3. <u>Artesian Ground-Water Horizon in the Upper Till in the Tillsonburg Moraine</u>

As has been already mentioned in Chapter 4, the upper till of the Aylmer-Brownsville area is massive without intercalated layers of stratified material, with the exception only of the Tillsonburg moraine (pages 17 and 33). The aquifer in the upper till of the Tillsonburg moraine is a thin intercalated horizon of varved clay and silt, and thus cannot yield too large an amount of water. It seems that it has some connection with the deeper artesian horizons, because the Tillsonburg moraine is too small to collect a sufficient amount of rain-water for a permanent artesian horizon, and the permanency of it is reported to be good. Thus there is a shallow well near the very top of the moraine 2-5/6 miles south of Aylmer (Concession V, Lot 11, Malahide Township, at Charles Woodcroft's farm, 788 feet above sea-level and about 40 feet above the surrounding plains) which is reported to be spring-fed thus supplying water with artesian pressure. Some of the springs around Summers' Corners may also derive from this

aquifer. According to the information given by Mr.G. Summers, these springs have continued flowing for at least sixty years without any change in their yield, indicating that their aquifer has not been influenced by the pumping of the Aylmer wells. (The Aylmer wells are 2 to 2½ miles north-west from Summers' Corners and receive their water from deeper artesian aquifers.)

4. The First Artesian Ground-Water Horizon

In the entire Aylmer-Brownsville area there is an extensive artesian ground-water horizon below the upper till. Except for the narrow ridge of the Tillsonburg moraine, it is the first artesian horizon from the top.

The aquifer of this artesian horizon is formed by the younger subhorizon of the lower till with its lenses of gravel and sand and the thin silty interstadial deposits at its very top (Chapter 4, Sections 2 and 3). Thus the aquifer cannot be considered as an uninterrupted layer. That makes it difficult to construct a contour map which would show the top of the aquifer. Well logs and geological investigation indicate that there are two principal levels of interconnected aquifers (Figs. 1 - 7):

(a) A relatively poor and often interrupted upper subhorizon just below the upper till in the lacustrine interstadial deposits. In some places it is dry, e.g., along Catfish Creek south-west of the mapped area (Fig. 8). It feeds a certain number of artesian wells around the airport and at Springfield. Being poor in water because of the fine-grained, silty material of which it is composed, it is influenced by fluctuations in piezometric surface more than the next deeper horizon. Thus wells fed by this subhorizon became dry first around the airport, due partly to intensive pumping in the lower subhorizon, and partly to a general lowering of the ground-water table in the whole area.

(b) The main subhorizon is in the middle and the lower part of the younger subhorizon of the lower till, probably consisting of gravelly and sandy lenses in it. The aquifer becomes more fine-grained in the western part of the area, particularly north-west of a line connecting Aylmer with Springfield. The yield of water is smaller there and farmers complain that fine sand and silt enter their drilled wells. If the main aquifer is not a continuous layer but rather a combination of lenses (e.g., it does not exist at Aylmer Well No.3a), the top of it is not as smooth as is indicated in the profiles, Figs. 1 - 7. These profile sections are intended to show merely the general outline of the top of this main first artesian horizon.

A great number of both drilled and dug wells are fed by this aquifer, among them Aylmer Wells Nos. 1-3, the Airport Well, and most of the flowing wells south-east of Springfield and at Brownsville.

Water of the first artesian horizon is relatively soft and suitable for consumption, but it is contaminated by sulphur water in several wells (Chapter 7, Section 8), particularly at Aylmer, where its piezometric surface is lowered by pumping and is consequently below the piezometric surface of the sulphurous bedrock water.

As the first artesian aquifer is younger than the buried interglacial lakeshore at Aylmer, it drops abruptly along it in a south-west direction, becoming both thicker and poorer in water below the shore line. The main aquifer of the first horizon is at a depth of 147 feet or more south-west of this buried shore, while its top is at a depth of 35 to 110 feet north-east of it (the greatest depth, 110 feet, is below the Norwich moraine). Connection between lenses of the aquifer seems to be greatly disrupted along the interglacial shoreline, thus preventing a continuous flow of water from the intake area in the north and north-east towards the south-west. Thus several test-holes drilled below the shoreline are completely dry.

5. The Second Artesian Ground-Water Horizon

The second, deeper artesian ground-water horizon is encountered by at least 70 drilled wells in the area north-east from the buried interglacial Lake Erie shoreline (Figs. 1-7). It is in the older subhorizon of the lower till, particularly near the top of this horizon. However, it seems to be connected also with lenses in deeper parts of the same till horizon, e.g., the well No. 139 (170 feet deep) has been influenced by pumping of Aylmer Well No. 3a (one mile west-south-west from No. 139), which receives water from the second artesian horizon at the depth of 82 feet (Fig. 1).

The aquifer is mostly gravel or gravelly sand with varying thickness (Figs. 1-7). At some places it squeezes out completely, e.g., west of Glencolin and north of Aylmer Well No. 3.

The most productive well of the area, Aylmer Well No. 3a, is fed by this aquifer; it seems that water flow in the aquifer is from north-east towards this well.

The depth of the top of the main aquifer of the second horizon is 80 to 100 feet below the surface. Its water is relatively soft, and there is only one report of its contamination by H_2S, though it is deeper than the first artesian aquifer and H_2S comes from the bedrock.

6. Artesian Ground-Water Along the Top of Bedrock

The next deeper ground-water horizon is in gravel on top of the bedrock, and in the bedrock itself. It has fresh water principally, but, as soon as the wells are pumped intensively, sulphurous water invades from underneath, and thus more than half of the producing wells from this horizon have sulphurous water (Chapter 7).

The piezometric surface of this horizon differs from that of the previous horizons in several cases Figs. 1-7). It is not as regular as the piezometric surface of overlying horizons, and shows changes even within short distances.

This ground-water horizon feeds, for example, the Carnation Company wells at Springfield and more than fifty farmers' wells, particularly along the north side of the Aylmer-Brownsville depression and along the Norwich moraine. It is generally a horizon rich in ground water, though with relatively hard water and a tendency to become sulphurous.

7. Sulphur Water

The so-called sulphur water contains H_2S, and smells like rotten eggs. Such water is not suitable for household consumption, but it is used for industrial purposes, for watering cattle and for irrigation if the amount of H_2S is not high. Sulphur water with a high H_2S content is said to possess medicinal value.

Sulphur water occurs principally underneath the fresh water in our area. It is encountered by nearly every gas well, either in bedrock or just above it, usually at a depth of 200 to 600 feet below the surface. Thus the bedrock surface may be considered as an approximate boundary between the fresh water and the sulphur water underneath it, though this boundary is neither regular nor permanent, as will be shown in the following discussion.

Sulphur water is under artesian pressure, and it rises to about the same level as the artesian fresh water or even higher. The artesian pressure, which is relatively irregular along the top of the bedrock, becomes more regular at greater depths.

There is an area at Aylmer where sulphur water rises at least twenty feet higher than the artesian fresh water. It coincides with the depression in the piezometric level of the artesian fresh water (see also Fig. 18). A recently drilled gas well (No. 541) on Concession VI, Lot 7, Malahide Township, 1-1/3 miles south-west of Aylmer, may be mentioned as an example of the relationship between the pressure of artesian fresh water and sulphur water at Aylmer.

It has encountered the following artesian horizons:

(a) fresh water at 115 - 158 feet; it rises to 35 feet below the surface;

(b) fresh water at 164 - 203 feet; it rises to 45 feet below the surface;

(c) sulphur water at 223 -231 feet; it rises to the surface.

The sulphur water is in gravel just above or in the bedrock. As this sulphur water is under a higher artesian pressure than is the fresh water, it may be forced into overlying fresh-water horizons if there are pore spaces or artificial openings (e.g., old drill-holes) connecting them. The beds between the artesian water-bearing horizons at Aylmer consist mostly of sandy till, which is relatively permeable, particularly if intercalated by lenses of sand and gravel and if these layers are either tilted or folded. Studies of the geological structure indicate existence of these features in the area under investigation.

Thus it is no wonder that sulphur water is encountered in four wells at Aylmer and north-east of it, even in the first artesian horizon which usually carries fresh water. These wells are:

(1) Aylmer Town Well No. 1 on Forest and Cedar Streets, 218 feet deep (drilled 1930)

(2) Aylmer Town Well No. 2 on Maple and New Streets, 212 feet deep (drilled 1931)

(3) Aylmer Town Well No. 3 on Concession VIII, Lot 15, Malahide Township, 1/4 mile north of C.N.R. 82 feet deep (drilled 1940

(4) Mr. Ch. Harp's well (No. 114), on Concession VII, Lot 15, Malahide Township, 175 feet north of Dingle Road, with sulphur water encountered at 82 feet (1918), but shut off by deepening the well to 122 feet.

Aylmer Well No. 3 had no sulphur water for the first few days after it was drilled. H_2S appeared at the fourth or fifth day, the same day when the water level in Clarence Strong's well, 1½ miles east-north-east from Well No. 3, was lowered 12 feet. That means that the test pumping caused such a drawdown in the piezometric surface of fresh

water of the first artesian horizon that sulphur water could be forced into this horizon. It penetrated to such an extent that even now the well is still contaminated by H_2S. According to the information given by Mr. S.R. McBrien, Superintendent of the Public Utilities Commission of Aylmer, the amount of H_2S is higher in Well No. 3 than in Wells Nos. 1 and 2. Thus it seems that the place of infiltration of the sulphur water or H_2S gas is closer to Well No. 3. It is probably between Well No. 3 and Aylmer, because no traces of H_2S are encountered in water of the same horizon in this vicinity in other directions from Well No. 3. It may be along the structural break at the buried interglacial shoreline (Figs. 1 and 3.)

According to information given by Mr. H.M.Nelson, sulphur water was encountered at a depth of more than 200 feet below the surface, when he drilled a new well on his farm in 1940, north of Dingle Road, about half a mile east from the intersection of Highways Nos. 73 and 3 at Aylmer. This water rose to about 50 feet below the surface, about 700 feet above sea level. As the static level of the nearby Town Wells No.2 (½ mile west-north-west) and No. 1 (2/3 mile west-north-west) is about 623 feet above sea level, it is evident that the difference of 77 feet in the artesian pressure between fresh water and sulphur water is favourable for the infiltration of sulphur water in overlying fresh water horizons.

No new artesian wells, taking fresh water or even slightly sulphurous water from the pleistocene deposits in large amount, should be drilled in future at Aylmer, in the area where the piezometric surface of sulphurous water is higher than that of fresh water horizons. New wells will lower the artesian pressure of fresh water and increase the infiltration of sulphur water into it.

Another area, where sulphur water rises higher than artesian fresh water, with a difference in piezometric surfaces up to 20 feet or slightly more, is around Brownsville.

Two gas wells on Concession XI, Lot 27, Dereham Township, may be mentioned as an example of the difference in artesian pressure of fresh water and sulphur water there:

	Well No. 624		Well No. 625	
	Depth of horizon (below earth's surface) (feet)	Piezometric surface (below earth's surface) (feet)	Depth of horizon (below earth's surface) (feet)	Piezometric surface (below earth's surface) (feet)
Bedrock	164		175	
Freshwater	170-180	24-17	177-198	30-20
Sulphur water	193	10	217	15

More than 100 gas wells (Photograph 24) and several water wells with sulphurous water are drilled down to the bedrock in this area. Several of these wells are flowing permanently (particularly gas wells) and thus decreasing the artesian pressure of sulphur water. It seems that at least some of these wells have contaminated the fresh water, even at relatively high horizons. Thus Mrs. A. Kaar's well (No. 477), Concession XI, Lot 22, Dereham Township, 2/3 mile south of Brownsville, which is only 22 feet deep, has sulphur water. Bedrock at that point is about 180 to 200 feet deep. It was reported that, since gas wells were drilled nearby (the closest ones are about 1/3 mile distant), the water in this well has traces of gas and a sulphurous taste in summer. Some other farmers of this area record similar complaints.

Another relatively shallow well (No. 520), 85 feet deep, with the bedrock at more than 200 feet, is 3/4 mile north of Brownsville, on Mr. W. Gilbert's farm, Concession X, Lot 21, Dereham Township. Two bedrock wells with sulphur water(No. 519a and No. 647), about 200 feet and 300 feet deep, are 1/2 to 3/4 mile north and north-west from this well. The first farm 1/3 mile west of the sulphurous well No. 647 has

a fresh-water well 150 feet deep (No. 646) which sometimes has had a sulphurous taste and once even an oily taste, in October, 1950. This relationship in location of sulphurous bedrock wells and shallower wells with sulphur water around them may indicate that sulphur water rises to higher fresh-water horizons along pipes of bedrock wells. Lack of systematic observations of these wells since the time they were drilled makes impossible a definite proof of this relationship; and such observations should be required, particularly in areas with gas wells.

There are four wells 2/3 to 1 mile west and south-west from Springfield, 180 to 220 feet deep (three Carnation Company wells, Nos. 321 - 323, and H. Bearse's well No. 88) which do not reach down to the bedrock but apparently receive water from the third lower artesian horizon which is both above and below the bedrock surface. A deeper sulphurous bedrock well (No. 90), 1,000 feet north-east from one of the above-mentioned wells (No. 88), shows a higher artesian pressure (12 to 21 feet higher) than the four shallower wells. Thus the difference in artesian pressure may cause a gradual rise of sulphurous water to higher levels.

There are four more wells in the central part of the Aylmer-Brownsville area, south-east of Springfield, 60 to 172 feet deep (Nos. 354, 444, 449, 517), which do not receive artesian water either from bedrock or pleistocene deposits just above it, but nevertheless show traces of H_2S. Water of all these four wells is relatively soft, which is characteristic for the first and second artesian horizon in this area, and thus indicates merely an admixture of H_2S from a deeper sulphur-water horizon. Insufficient information makes it impossible to explain this admixture in each of these wells.

In most cases of sulphur water in higher horizons it is, however, obvious that it derives from the deeper-lying sulphur water, which is principally below the bedrock surface.

Judging only from the data of non-producing test holes, the artesian horizon along the bedrock surface, including gravel just above it and limestone just below it (even down to 65 feet below the top of bedrock in an extreme case) can supply fresh water. Thus 72 test holes out of 80 around Brownsville had fresh water at the above-mentioned depth, four had both fresh water and sulphur water, and four only sulphur water. However, if we compare producing water wells of the same horizon in the Brownsville area, most of them (13 out of 17) yield sulphur water. That supports the conclusion that intensive pumping of those fresh-water horizons which are connected with a sulphur-water horizon may induce H_2S in the fresh-water horizon.

It is suggested that drilling for fresh water down to the bedrock or even down to the gravel layer just above it should be avoided if possible, because the well may yield sulphur water, either just after drilling or later. If a horizon with sulphur water is reached, the casing should be left in its entire length. If the casing is pulled out, the sulphur water has free connection to other aquifers and may contaminate fresh-water horizons. This rule applies also to test holes and gas wells.

In areas where piezometric surfaces of both artesian fresh water and sulphur water are the same or where the sulphur water is under a higher pressure, no strong draw-down should be permitted in deep fresh-water wells. It may cause such a lowering of the piezometric surface of the fresh water that the normal equilibrium between the two types of artesian ground-water horizons is destroyed and the sulphur water may be forced into fresh-water horizons, as has happened at Aylmer.

8. Oily Fresh Water

Another source of contamination of deeper fresh-water wells may be oil, which is encountered sporadically and in small quantities in bedrock of the Aylmer-Brownsville area, particularly between Springfield and Aylmer.

There are seven fresh-water wells with traces of oil in this area, which is about three miles long and one and a half miles wide, five of them reaching down to, or even into, the bedrock. One of them, on M.W. Mann's farm, Concession X, Lot 14, Malahide Township, has about one foot of oil on the top of water. Two of them are shallower:

(a) On F. Hume's farm, Concession XII, Lot 10, South Dorchester Township, 149 feet deep (with bedrock at a depth of 240 feet), which shows oil periodically;

(b) On A.S. Hare's farm, Concession IX, Lot 11, Malahide Township, at Highway No. 73; it showed oily water at a depth of 50 feet in 1902, but has no traces of oil now, since it has been deepened to 110 feet.

As oil has a tendency to rise through pore spaces, it may be that all the above-mentioned wells receive it from related thin oil pockets in the bedrock.

9. Salt Water

No salt water is encountered in water wells of the Aylmer-Brownsville area. There are, however, three test holes, drilled for gas, where salt water is reported at a depth which is shallower than some of the deepest water wells of this area (though not near the test holes).

Particulars of these three wells, in the Brownsville area are as shown in the table on the following page.

Well	Depth below the earth's surface (Ft.)			
	Bedrock Surface	Deepest Fresh Water	Sulphur Water	Salt or Brackish Water
R.L. Pattison's Well (No. 556), Dereham Tp., Con. XII, Lot 24, 350 feet north of south line, 350 feet west of east line, drilled 1939, 780 feet above sea level	174	190	-	210
C. Turner's Well No. 1 (No. 642), Bayham Tp., Con. X, Lot 2, east ½	192	204	-	220
A. Berdan's Well No. 2 (No. 635), Con. XII, Lot 24, south ½, 350 feet from north line, 350 feet from east line, 769 feet above sea level	163	145	-	* 210) ** 280)

* brackish water ** black salt water

In other wells salt water is encountered at a greater depth, e.g., 500 feet, 950 feet, etc.

Though no fresh-water wells have been contaminated by salt water in the Brownsville area, its presence at a relatively high level should be kept in mind.

TABLE II

SUMMARY OF WELL DATA

	Aylmer	MALAHIDE TP. Con.V	Con.VI	Con.VII	Con.VIII	Con.IX	Con.X	S. DORCHESTER TP. Con.X	Con.XI	Con.XII	DEREHAM TP. Con.IX	Con.X	Con.XI	Con.XII	BAYHAM TP. Con.IX	Con.X	Total No. in the area	Per cent of total
Total Number	2	16	54	36	69	82	80	17	29	49	12	23	29	6	6	1	511	
Dug	-	7	30	25	35	32	15	2	8	16	3	1	5	4	5	1	189	37
Drilled or bored	2	1	4	7	29	46	58	14	21	32	9	22	23	1	1	-	270	53
Driven	-	8	12	1	3	2	2	-	-	1	-	-	1	1	-	-	31	6
Springs	-	-	8	3	1	2	2	1	-	-	-	-	-	-	-	-	17	3
Unknown	-	-	-	-	1	-	3	-	-	-	-	-	-	-	-	-	4	1
Wells 0-40 feet deep	-	15	48	25	42	38	36	3	8	19	3	1	7	5	5	1	256	50
41-80	-	-	2	3	10	8	9	-	4	9	-	7	7	-	1	-	60	12
81-120	-	1	-	2	5	8	14	2	5	7	3	5	4	-	-	-	56	11
121-160	-	-	1	3	2	6	4	2	1	5	2	1	2	-	-	-	29	6
161-200	-	-	1	-	5	4	5	2	4	1	1	3	3	1	-	-	30	6
over 200	2	-	1	2	4	12	10	7	2	7	2	5	2	-	-	-	56	11
depth unknown	-	-	1	1	1	6	2	1	5	1	1	1	4	-	-	-	24	4
Wells with hard water	2	10	37	20	32	36	37	8	9	24	5	2	10	4	6	1	243	48
soft and medium hard water	-	6	15	13	29	31	41	9	16	20	6	17	16	2	-	-	221	43
sulphury water	2	-	-	-	4	3	8	3	2	4	2	6	7	2	-	-	43	8
oily water	-	-	-	-	-	4	1	1	-	1	-	-	-	-	-	-	7 *	1
unknown	-	-	2	3	6	8	2	-	3	2	-	-	-	-	-	-	26 *	5
**)Flowing wells and springs	-	-	9	3	2	7	13	1	-	2	-	7	12	-	-	-	56	11
**)Non-flowing artesian wells	2	1	6	13	27	44	47	14	20	32	9	15	9	1	1	-	241	50
**)Non-flowing non-artesian wells	-	15	39	20	29	26	16	2	8	11	3	1	7	5	5	1	188	39
Wells with permanent supply	-	15	46	28	43	55	68	16	24	43	11	23	27	5	4	1	409	80
non-permanent supply	2	-	2	2	9	6	1	-	2	1	-	-	-	1	-	-	26	5
Dry holes ***)	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	
Abandoned wells ***)	-	-	3	2	9	14	3	1	2	4	1	-	1	-	2	-	42	8
No information re permanency	-	1	3	4	7	7	8	-	1	1	-	-	1	-	-	1	34	7
Aquifer: sand	2	14	33	18	23	17	24	1	3	11	1	2	2	-	-	-	151	30
gravel	-	1	6	10	19	17	19	3	7	13	-	7	7	2	2	-	113	22
clay or till	-	1	4	3	2	8	2	1	2	2	-	-	2	-	-	-	27	5
Unknown Pleistocene deposits	-	-	10	5	22	31	33	9	16	17	6	8	12	3	4	1	177	35
Bedrock (Dev. limestone)	-	-	1	-	3	9	2	3	1	6	5	6	6	1	-	-	43	8
Pump and its power: **)																		
handpump	-	8	14	11	19	25	13	2	2	14	3	2	1	4	1	1	120	29
electric p.	2	6	23	17	27	35	48	14	18	26	7	14	16	2	1	-	256	61
windmill	-	1	1	1	5	2	3	1	2	2	1	1	1	-	-	-	21	5
gas motor	-	1	-	-	-	-	-	-	1	1	-	-	-	-	1	-	4	1
unknown	-	-	-	-	2	2	2	-	2	1	-	4	3	-	1	-	17	4

* Oily and in many cases sulphury water is counted twice: as oily or sulphury and as either hard or soft

** The most of abandoned wells are excluded from this classification due to lack of information

*** The number of dry holes and abandoned wells should be higher, because many of them were not recorded

CHAPTER 7

LOWERING OF THE GROUND-WATER LEVEL

It is widely accepted that the ground-water level and the piezometric surface of artesian water is becoming lower in densely populated areas (A.K. Watt, 1946 and 1950; G.D. Clyde, 1950; et al). A great number of farmers of the Aylmer-Brownsville areas, particularly older settlers, claim the same, but not all of them can supply exact data on the changes in the ground-water level.

The main reasons for the lowering of the ground-water level are the following:

(a) Cutting down of forests, and increase of artificial drainage, which causes a more rapid run-off and allows less water to percolate into the ground.

(b) Increased consumption of ground-water by both farmers and municipalities.

Silting of old wells and clogging of their screens may also decrease the pumping rate in some cases without any lowering of ground-water level.

Though all these reasons may cause lowering of the water level in wells or a decrease in pumping rate, it is difficult to tell which of them is the main cause in each individual case.

The farmers between Aylmer and Springfield, particularly around the airport, allege that the Aylmer town wells (particularly No.3), the Airport Well, and the Carnation Company wells have lowered the ground-water level or the piezometric surface of artesian wells. Both Map 10 and the profile section No. 18, based upon data of several wells, seem at least partly to support this charge.

Springfield derived its name from its springs. Most of them are reported to have ceased to flow after deep wells were drilled, 1895 to 1900, at Springfield.

However, in the area with most complaints about drying out of farmers' wells by Town Well No. 3 and the Airport Well, most of the farmers' wells which became dry or lowered their water level have been dug or drilled down only to the top of the lower till or into poor pockets in the upper till. Without reaching down to the main first or second aquifer, they would, sooner or later, become dry or less productive even if no town or airport wells had been drilled there, because their aquifers were relatively poor in water.

No sufficient information re changes of water levels has been recorded in that part of the Aylmer-Brownsville area which is farther from the above-mentioned high-producing wells. Most of the farmers, particularly those who have not been long on their farms, did not know of any regular changes in water level, or their reports were controversial: e.g., around Summers' Corners, one neighbour reported lowering of the water level while others did not. No important lowering of the water level was reported in the area north-west of Brownsville and on the Tillsonburg moraine south of Aylmer, even by older settlers.

Further lowering of ground water, even where it has resulted in the drying out of farmers' wells, may be prevented by conservation measures, such as reforestation, wide spacing of highly productive wells, planned exploitation of different ground-water horizons, and artificial recharge of ground-water. Some of these measures will be discussed in the following chapters, which will deal with areas with the most noticeable lowering of ground water in the past few decades.

CHAPTER 8

AYLMER AND AIRPORT WELLS

As the wells which supply the town of Aylmer and the airport south of Springfield are the most productive ones of the Aylmer-Brownsville area, they will be discussed in some detail. Information regarding the town wells is given, for the most part, by Mr. S.R. McBrien, Superintendent of the Public Utilities Commission of Aylmer, and by International Water Supply Limited, London, Ontario.

1. The Old "Flowing Well"

The first source of municipal water supply for the town of Aylmer was a flowing well on the McEwen farm about 30 feet south-west from the present Town Well No. 3. However, no reliable information on this old flowing well is available. The supply from this well apparently became insufficient around 1908, because at that time the Public Utilities Commission started looking elsewhere for water. In 1939, when Mr. S.R. McBrien arrived at Aylmer, there was some water in the well, about 12 to 16 feet in depth. It was filled the same year because a new more productive well was drilled near it (No.3).

2. Town Wells Nos. 1 and 2

Town Well No. 1, 218 feet deep, was drilled by the Layne Bowler Company of Canada, in the north-west part of Aylmer (near Forest and Cedar Streets) in 1930.

Elevation of Well No. 1 is 757.8 feet above sea level. Water apparently comes from the depth of 147 to 192 feet where intercalated sand, gravel, and clay are reported by the log of a test hole 15 feet from the well. This aquifer belongs to the first artesian horizon. The pumping rate, according to the Water Well Record at the Ontario Department of Mines, has been 250 Imperial gallons per minute, with draw-down 141 to 146 feet below the surface. The static level of this well has been always similar to that of Well No. 2; thus it is assumed to be about 135 feet below the surface at the

present time. The air gauge of Well No. 1 is quite inaccurate and thus it is impossible to obtain exact data at the present time. It operated from 1931 to 1942, but pumped sand, and its water was slightly sulphurous. As the Layne Bowler Company of Canada has ceased to operate and the driller's logs of 1930 did not seem to be very reliable, three test holes were drilled around the well by International Water Supply Limited in November 1944. They did not indicate a prospect of greatly increasing the yield of this well. Mr. S.R. McBrien believes that the structure of the aquifer, which consists of layers of sand between layers of clay, causes acceleration of the flow of sand into the well when the drawdown becomes too severe. Thus, since 1942, it has been operated only occasionally and for short periods, less than ten hours at a time.

As Well No. 1 was not sufficient for the town's water supply, a new well, No. 2, 212 feet deep, was drilled in 1931 by International Water Supply Limited, on the west side of Maple Street, near Walnut Street. The elevation of the well is 752 feet above sea level. The aquifer, consisting of interstratified sand, gravel, and clay, is at a depth of 175 to 201 feet. The bottom of the screen is at 187¼ feet. The static level was 45 feet below the surface in 1931. During the pumping test at a rate of 200 Imperial gallons per minute the drawdown was 105 feet (down to 150 feet below the surface). Another pumping test (1939) proved a possible production of 497 Imperial gallons per minute. However, this well began to pump sand in 1940, when both wells (No.1 and No.2) were operated to yield over 70,000,000 Imperial gallons annually. Another similarity with Well No.1 is the sulphurous water and it seems that both wells receive water from the same aquifer.

In 1945 Well No. 2 was rehabilitated, and now it is used for town supply again, though not permanently, yielding about 17,000,000 Imperial gallons annually. It is pumped at a rate of 200 Imperial gallons per minute. After several hours' pumping the water level lowers so far that the

pumping is stopped at the level of 164 feet below the surface, in order to prevent the pump sucking air. The static level of Well No. 2 has lowered 84 feet in the last nineteen years, and was 129 feet below the surface in November 1950.

Some farmers just north and east of Aylmer claim that Town Wells Nos. 1 and 2 have dried their wells. Thus Mr. H. Ackert reported that his 90-foot well (No. 65, 3,800 feet north from the intersection of Highways No.3 and No. 73 at Aylmer, and 200 feet west from Highway No. 73) had about 70 feet of water before the town wells were drilled. The first town well lowered the water level about 20 feet and the second well has dried it completely.

A similar report comes from Mr. H.M. Nelson. His well (No. 314, ½ mile east from the above-mentioned highway intersection) was about 72 to 78 feet deep, with the water level about 10 feet below the surface, and it also was drained after Town Well No.2 was drilled.

It seems that both these wells received water from lenses or a restricted water-bearing horizon in the upper part of the lower sandy till, and that they were drained by the lowering of the piezometric surface around Town Wells Nos. 1 and 2. It could not be the main first artesian aquifer, because the present static level, e.g., at Mr. Nelson's new deeper well (No. 313), is higher than the bottom of the drained old well.

3. <u>Town Well No. 3</u>

As both wells, No. 1 and No. 2, were not sufficient for Aylmer's water supply, and as their water was sulphurous, the Town of Aylmer decided to look for additional supply. Five test holes were drilled by International Water Supply Limited, in 1939, and a new well (No. 3) was established on Concession VIII, North Gore, Lot 15, Malahide Township, ¼ mile north of The Canadian National Railway tracks, 1-2/3 miles north-east of Aylmer.

The elevation of this well is 756.4 feet above sea level, its depth is 82 feet 6 inches, with water-bearing sand (of the first artesian horizon) at the depth of 65 to 80 feet, and with till underneath. The static level was 8 feet below the surface in 1940. While test-pumping at the rate of 500 Imperial gallons per minute (production capacity of the well), drawdown was down to 37 feet below the surface.

As already mentioned on page 45, the water was fresh during the first four days of test-pumping. Then it became sulphurous due to a strong drawdown which caused infiltration of sulphur water. Though sulphurous, this water was used for the supply of Aylmer until March 1, 1949. The static level lowered in this well with every year. It was as follows:

December 1939	8 feet below the surface
November 1948	23 feet below the surface
December 1948	25 feet below the surface (after the test-pumping of Well No. 3a)
November 1950	29 feet below the surface (though well not used since 1949)

As the lowering of the static level continues up to the present time, though the well has not been used since March 1949, it must be caused by pumping from another active well. Lowering could not be caused by the intensive pumping of the new well, No. 3a, because both the static and the pumping levels of Well No. 3A are higher (its static level was 733 feet and pumping level 729 feet above sea level in 1950, while the static level of No. 3 was 727 feet above sea level at the same time). Discussions on the Airport Well (see the next chapter) indicate that the static level of Well No. 3 is lowered by the Airport Well, and perhaps by Town Well No.2.

Water of Town Well No.3 was analyzed by the Department of Health, October 9, 1941 (Lab. No. W92). Results of the analysis are as follows:

Hardness (soap cons. p.)	144 p.p.m.
Alkalinity	204
Solids	293.0
Solids, ignited	204.2
Solids, loss on ignition	88.8
Fe	0.05
Al	0.5
Ca	39.1
Na	38.1
Mg.	11.1
SO_4	21.2
SiO_2	9.2
Cl	6.0

4. R.C.A.F. Airport Well

Another relatively high-producing well of the same area near Aylmer is at the R.C.A.F. airport, about one mile north of Town Well No.3. It was drilled by International Water Supply Limited in 1943, and is 69 feet deep. Its elevation is 776 feet above sea level, the aquifer is fine sand at a depth of 60 to 69 feet, and it is apparently fed by the same first artesian horizon which feeds the town wells, No.3, and Nos. 1 and 2. Its static level was 21½ feet below the surface in 1943, with a drawdown to 58½ feet below the surface at a pumping rate of 92 Imperial gallons per minute.

According to data kindly supplied by the R.C.A.F., its static level has lowered steadily:

1943	--	21½ feet	below	the	surface
1944		26 feet	"	"	"
1945		28 feet	"	"	"
1946		32 feet	"	"	"
1947		35 feet	"	"	"
1948		38 feet	"	"	"
1949		40 feet	"	"	"
1950		44 feet	"	"	"

The pumping level was 63 feet below the surface in 1950.

If we compare the amount of lowering of the static level of both the Airport Well and Town Well No.3 in the last year, when Well No. 3 did not operate, it is obviously the same, viz., four feet. Thus the drawdown at Town Well No. 3 seems to be caused mainly by the Airport Well.

Production of the Airport Well is about 60,000 gallons a day in summer and about 45,000 in winter. Yearly gallonage figures for the last years are as follows:

1946	-	19,911,700	gallons
1947	-	16,388,100	"
1948	-	11,987,200	"
1949	-	15,629,100	"
1950	-	14,343,600	" (to November 2)

Although the amount of water drawn from the Airport Well is decreasing, the static level is being lowered rapidly, and the drawdown level is now only 6 feet above the

bottom of the well; sand is being pumped together with water. All these facts indicate that the well is strongly overworked, and that a new well will soon be necessary for the airport.

Both Town Well No.3, which operated from 1940 to 1949, and the Airport Well, operating from 1943 up to the present time, have lowered the piezometric surface in the first artesian horizon, from which they receive water (Figs. 1-4, and 18). This lowering was noted in farmers' wells in an area up to 2½ miles in the north-east direction and 4/5 mile in the west direction around these two wells. Of course, many of the affected wells were too shallow, ending either in the upper till or in the relatively poor subhorizon just below the top of the upper till. They would have dried out by even a slight increase of consumption by farmers themselves. However, those wells which reach down to the main first artesian aquifer were also affected, though without completely losing water.

5. Town Well No. 3A

Since Well No. 3 did not satisfy the requirements of the Town of Aylmer, new test holes were drilled by International Water Supply Limited, around Aylmer in 1944 and 1945, and a new well was established in 1947, 1,000 feet south of Well No.3. It is called No. 3A, is 109½ feet deep and has artesian water, coming from coarse gravel belonging apparently to the second artesian aquifer, at a depth of 82 to 107 feet below the surface. Its elevation is 755.2 feet above sea level. Though the aquifer of Well No.3 A is only a little deeper than the aquifer of the neighbouring well No.3 (65 to 80 feet below the surface), they belong to different artesian horizons. The water of Well No. 3A is softer than that of Well No.3, and is fresh (see the analysis on pages 57, 61), while the water of Well No. 3 is sulphurous; and the two wells have different artesian pressures: it is higher at Well No. 3A, even when it is operating (Fig. 18).

Well No. 3A has been used since March 1948; it can yield 1,000 Imperial gallons per minute, and is supplying the Town of Aylmer with about 220 million gallons per year.

The static level was 15 feet below the surface when the well was completed; and the drawdown was reported to be 29 feet below the surface at a pumping rate of 790 Imperial gallons per minute (Water Well record, Ontario Department of Mines). The static level has lowered to 22 feet below the surface in 1950, but the drawdown is at present only down to 26 feet below the surface.

It was reported by Mr. S.R. McBrien, that during the test pumping of Well No. 3A in 1948, the water level of the neighbouring Well No.3 was lowered 2 feet, and it never came back. However, there is some doubt whether this lowering was caused by the test-pumping alone, and whether there was not some influence of the Airport Well, which pumps from the same horizon as Well No. 3.

If there is some connection between the first and second artesian horizons, it is not near Wells Nos. 3 and 3A, because they have different water. The possible connection between these two aquifers could be farther north (north of Springfield) or north-east.

There have been no complaints from farmers, who receive their water from the same second artesian horizon as Well No. 3A, that their water level has been lowered, though the town well is pumping at a high rate. These facts indicate that this aquifer is rich in water.

There is one well which is reported to have a lowered water level after Town Well No. 3A was drilled: Mr. J. Flagel's well (No. 139), 1 mile east-north-east from No. 3A, on Concession IX, Lot 19, Malahide Township. However, this well is 170 feet deep, and accordingly draws from an aquifer twice as deep as that of Well No. 3A. It seems to be a lens, connected with the main second aquifer, but not the main aquifer itself (Fig. 4).

Water of Well No. 3A was analyzed by the Imperial Leaf Tobacco Co. Ltd. on January 23, 1950. The report is as follows:

Colorless water with some light brown suspended solids.

Total dissolved solids (in grains per U.S. gallon)	12.2
" hardness (as Ca Co3)	5.3
Non-carboniferous hardness	0.0
Ca hardness (as Ca Co3)	2.5
Mg "	2.6
Phenophtalein alk.	0.o
Total alk. (M.O)	10.1
Free CO2	0.3
Chlorides (as NaCl)	0.3
Sulphates (as Na2 SO4)	0.3
P.H. = 8.0	

6. Possibilities of Additional Ground-Water Supply for the Town of Aylmer and the Airport

Though the Town of Aylmer has sufficient water at the present time, even during the season of most intensive industrial activity in the summer months, further development of the town of Aylmer may some day require a larger amount of water. The available data regarding the structure of pleistocene deposits and ground-water horizons in them permit us to draw the following conclusions:

(a) The area north-west, west, south-west, and south-east of the town is not favourable for greater ground-water supply, for the following reasons:

(1) The artesian water-bearing horizons are mostly sandy or silty with low permeability, or in the form of lenses, and several deep test holes south and south-east of Aylmer are completely dry; thus no great amount of water could be expected there; the present drawdown of the intermittently operating Town Wells No. 1 and 2 is so strong that even they cannot be operated continuously.

(2) The strong drawdown in these poor aquifers has caused invasion of sulphur water in the fresh-water horizon, and it may spread further if new deep wells are operated there.

(3) Though no lowering of the water table of the non-artesian ground-water is reported from the sandy area south of Aylmer, no data are available as to how rich this shallow surface horizon may be; as the area is populated, this water is liable to contamination.

(b) The area between the town and Wells Nos. 3 and 3A is not very good either because of the increased consumption of ground water by individuals and municipalities in this area (page 52, point (b)).

(c) The most favourable area for additional water supply is probably in the north-east or east-north-east direction from Wells Nos. 3 and 3A. There are two main artesian fresh-water horizons in this area (Chapter 7, Sections 5 and 6). The richer of them, and the one less exploited by farmers, is the second.

If a new high-yielding well (producing at least 500 Imperial gallons per minute) is to take water out of the second horizon, it must be located so far from Well No. 3A that the drawdown of either of them would not influence the other. The distance depends greatly upon the permeability and thickness of the aquifer (it is highly permeable gravel, 25 feet thick at Well No.3A). Thus test-pumping at several points north-east and east of Well No.3A would be desirable.

As the Airport Well may become insufficient in the near future, due to increased drawdown and sand pumping, the airport will have to look for a new well, drawing probably from the same second artesian horizon. Though no water in the first and second aquifers was reported by the well-driller E. Hoover, of Aylmer, in G. Hupleigh's well midway between Well No. 3A and the Airport Well, the existence of the second artesian horizon in other wells near the airport (Figs. 1-6) suggests a possibility that it does not taper out under the airport.

In order not to draw too much from the deeper, second artesian horizon, the town could use the upper, first horizon additionally, at a point not too close to Wells Nos. 1-3, since their water is sulphurous. As this horizon is not as rich as the second one and is more used by farmers, it should be recharged artificially by letting in surface water.

CHAPTER 9

ARTIFICIAL RECHARGE OF THE FIRST ARTESIAN HORIZON NORTH-EAST FROM AYLMER

As already mentioned, the first artesian ground-water horizon can be used for additional water supply, provided only that the amount of water which is taken out must be replaced by surface water. Otherwise, intensive pumping will lower the piezometric surface of this horizon, and thus will affect the water level in many farmers' wells. The Town of Aylmer is aware of these facts, and they are prepared to start ground-water recharge if the geological conditions are favourable, and if they require to use water from the first artesian horizon again.

Looking for a suitable place for these purposes, the Public Utilities Commission selected the area just east and north-east from Clarence Strong's farm in the central part of Concession IX, Lots 22-24, Malahide Township. This area is wooded, and is at the junction of Catfish Creek and an intermittently flowing creek which comes from Springfield, and also some permanently flowing drainage ditches. The ground is till with a cover of about 4 to 6 feet of either alluvial loamy bottomland or lacustrine clay (up to 3½ feet) with sand (2 to 6 feet thick) on the top (sand is up to 9 feet thick along the L. Arkona spillway bank - Map 1). The stratigraphical sequence may be seen in profile 1 between Nos. 174 and 297.

The top of the first artesian aquifer is at a depth of 36 to 38 feet in the test holes Nos. 29 and 30 (Fig. 1), and the top of the lower till seems to be at a depth of 32 feet below the surface in the test hole No. 29 (International Water Supply test No. 15, November 27, 1945). It would be very important to find the top of the lower till, as well as the top of the main aquifer, by several additional test holes, because these data will indicate the level where the recharged water may infiltrate.

The log of the gas well (No. 297) on Concession VIII, Lot 25, Malahide Township, which is at the very east end of the concession, gives 20 feet of sand at the surface, in contrast with the surface observations along the Catfish Creek close to the same place, e.g., No. 142a:

No. 142a	No. 143
2 feet sand	1 foot sand
2 feet varved clay and silt	2 feet brown clay
3 feet slump	½ foot coarse sand
	½ foot till

Though it is desirable that additional test holes should be drilled, even the information already available regarding the geological structure and the ground-water horizons indicates that the above-mentioned area, chosen by the Public Utilities Commission of Aylmer, is suitable for ground-water recharge.

The factors in favour are as follows:

(a) Junction of creeks and drainage ditches, which assures a sufficient amount of water for recharge throughout the year;

(b) Sand cover on top of clay and silt, particularly upstream along the Catfish Creek for several miles, which decreases the amount of silt in the water, with the exception of the creek coming from Springfield;

(c) Depth of the top of the main first aquifer seems to be 33 to 40 feet, which is the minimum depth for the first artesian horizon of the Aylmer-Brownsville area;

(d) It is far enough (about two miles) from the closest sulphurous well No. 3; as the recharge of the first artesian aquifer with piezometric level at least 20 feet above the top of aquifer must be connected with the pumping of water nearby in order to create space for recharge, this factor should be kept in mind.

There are different methods of ground-water recharge. F.H. Klaer, W.F. Guyton, and D.K. Todd (1948, pages 2-3) classify them in the following groups:

(1) Water spreading

- a Flood method
- b Basin method
- c Ditch and furrow method
- d Natural channel dispersion
- e Irrigation method

(2) Recharge by pits and excavations

- a Pits excavated for recharge purposes
- b Pits excavated for other purposes
- c Brine and industrial waste disposal pits

(3) Recharge through wells and shafts

- a Disposal wells for recharge purposes
- b Drainage wells for disposal of excess water, sewage and industrial wastes
- c Shafts
- d Brine disposal wells

(4) Induced recharge by pumping

In order to see the advantages and disadvantages of different types of ground-water recharge installations and their use, depending on different geological structures and different kinds of water, the author of this paper was sent by the Ontario Department of Planning and Development to several places in the eastern United States, as well as to offices of the Geological Survey of America to consult with their ground-water experts. It turned out that most of the ground-water recharge installations in the United States are in areas with permeable material between the recharged ground-water table and the earth's surface. Thus the problem of recharge is solved much more easily in such localities than at Aylmer, where 30 to 40 feet of impermeable till lies between the earth's surface and the first artesian horizon which is to be recharged. After discussions with several G.S.A. officers, the author of this paper came to the conclusion that either pits or shaft-like bore-holes with large dimensions, filled with gravel down to the aquifer, would be the most suitable construction for this particular case.

Filling a pit with gravel prevents the caving in of its walls and the silting of the pit at a depth (30 to 40 feet) where the removal of silt is very difficult or even impossible if the silting begins to reach into the aquifer from the bottom of an open pit. If a pit or shaft is filled with gravel it will work like pits dug in gravel, the only

difference being that water cannot percolate in a lateral direction if walls of the pit are of till. According to information kindly supplied by the Ground-Water Branch of the U.S. Geological Survey, shafts or drill-holes with a large diameter (30 inches) are used successfully for ground-water recharge by the Los Angeles County Flood Control District, in California. These holes are drilled at the bottom of a recharge basin through an impervious layer and are then filled with pea gravel to afford permeable conduct. In order to prevent silting inside the holes, the top of the gravel covers the hole in a small mound and can be replaced if it becomes silted. The disadvantage of drill holes compared with larger pits is the smaller storage space for recharged water, particularly if the drawdown of the static level does not reach into the aquifer. Thus the question which arises is: which method will give the largest space for recharge at the lowest cost?

The size of the pit or the number of smaller shafts will depend upon the following factors:

(a) The rate of percolation, which is related mostly to the permeability and total pore space of the gravel; the percolation rate usually decreases with time on account of silting and other changes in soil structure.

(b) The drawdown of the piezometric surface of the first artesian horizon by a discharge well; a strong drawdown will increase the potential storage space for recharged water.

(c) The amount of water which is available for recharge.

The actual rate of percolation is not known in the proposed recharge installations at Aylmer, and it depends not only upon the pore space in the material and the quality of the water (hardness, silt content, organic matter, etc.), but also upon the piezometric surface of the artesian ground water which is to be recharged. Assuming that the piezometric surface may be lowered sufficiently, experiments with gravelly ground at other places could be used for a theoretical calculation of the size of a recharge pit. Experiments in California, e.g., at Azusa, give a relatively low rate of percolation: 3.77 acre feet per acre per day in disturbed coarse gravel (A.T. Mitchelson and D.C. Muckel, 1937, pages 63-68).

According to the information kindly supplied by Mr. F.H. Klaer, Jr., District Geologist of Indiana, the rate of percolation has been at least three times the value cited above, in a recharge pit, 60 feet square and 20 feet deep, at the Miles Laboratory, Elkhart, Indiana: 400 gallons per minute or 11 acre feet per acre per day, assuming percolation not only through the bottom but also through the walls. This pit has been used successfully for five years.

According to information kindly supplied by Mr. M. Suter, from the State Water Survey Division, Urbana, Illinois, the Survey expects an even higher rate of percolation in their new recharge pit: 1-2 million gallons per day in a gravel-filled pit with a bottom area of 2,500 square feet. That means an average percolation rate of about 96 acre feet per acre per day, or about 25 times the rate in the above mentioned-example from California. This calculation is based upon experiments at Peoria, Illinois, in 1941.

These three examples show that it is difficult to estimate the rate of percolation in a new place without a detailed survey of all the factors involved.

Assuming the minimal rate of percolation from the above-mentioned example of Azusa, California, a pit 2/3 acre in size (or a set of smaller shafts with the same surface of percolation) will recharge about as much water as is consumed by the town of Aylmer at the present time.

Of course, that is merely a theoretical assumption, in order to give an idea of how large the recharge pits should be.

The problem of preventing the decrease of the rate of percolation (factor (a) above) will be discussed more in detail, being one of the most serious problems of recharge installations. One of the main causes of decrease of percolation rate is silting. However, it should be borne in mind that not only mechanical silting but also change in soil structure,

bacterial activity, and chemical changes in soil (accumulation of iron hydroxide, calcium carbonate, etc.) may cause a decrease in the infiltration rate. In order to prevent the decrease of the rate of percolation in recharge basins, the following measures have been found useful:

(1) The installation of one or more still-pools upstream, depending upon the amount of silt carried by creeks and ditches. Silt settles there before the water enters the recharge basin. Such still-pools are in use on Long Island, New York, (Photographs 28 and 30) at East Orange, New Jersey, (Photograph 27) and in other places where storm water or run-off from farmland is used for recharge of ground water. Silt can be removed from the still-pool periodically by letting rapid storm water through the pool or by digging it out. No information regarding the amount of silt in the Catfish Creek and its tributaries has been available to the author of this paper. However, casual observation of the area around Catfish Creek seems to point to the following conclusion: if a recharge basin is installed below the junction of the Catfish Creek and the creek which comes from Springfield, still-pools should be installed on both of them, particularly on the latter, which carries more silt. If Catfish Creek alone provides a sufficient amount of water for recharge, the more silty run-off of the Springfield Creek should be left unused.

Ditches connecting the creek with the recharge basins at East Orange, New Jersey, run along the contours, thus preventing a fast flow and permitting the settling of silt on the way to the recharge basin. These ditches are periodically cleared of silt.

(2) In spite of these preventive measures, some amount of silt will reach the recharge basin and gradually accumulate on its bottom and in the pore spaces of the upper part of the gravel and sand. In the recharge basin at Runyon,

Storm-water recharge basins, near Mineola, Long Island. A still-pool at the left, recharge basin at the right, temporarily dry, with scarified surface.

Recharge basin, dry, with scarified surface. Mineola, Long Island.

New Jersey, a surface layer of sand at least one foot in thickness is completely silted. Nevertheless, the basin has been operating successfully for at least fifty years, recharging the sandy aquifer (H.C.Barksdale and G.D. Debuchananne, 1946, page 727). The explanation seems to be in the shallowness of the recharge basin (about two feet deep) and thus its bottom is covered by a thick mat of vegetation. The above-mentioned authors assume (page 736) that root holes of plants, growing in the pond, make the silted bottom of it permeable. Thus shallow water with a natural growth of plants on the bottom of the basin makes the silted top of sand or gravel permeable. Of course, recharge basins with artificial gravel filling will have no vegetation at first, and some other method may then be necessary to prevent decrease of percolation.

(3) In many places, the silted top layer of recharge basins is deeply scarified, scraped, or spaded, or the silt layer is removed from time to time, the basins being periodically allowed to dry out (Photographs 28-29). This method, however, involves additional expense, and makes it impossible to maintain a cover of vegetation in a shallow basin.

(4) Among other methods some very promising experiments were reported by Mr. D.C. Muckel at the meeting of the American Society of Civil Engineers at Los Angeles, California, in April 1950, and by Mr. G.D. Clyde at the Annual Meeting of the Soil Conservation Society of America, Detroit, Michigan, on October 28, 1950. Let us quote a part of Mr. Clyde's typed report, pages 6-7:

> "In 1944 a co-operative research project was started by the Soil Conservation Service, the North Kern Water Storage District, and the State of California near Bakersfield, California, to determine the causes of the decreased infiltration rates and to develop methods and management practices that would maintain high infiltration rates. Two sets of test ponds were built on different soils using different spreading water. These test ponds were set up to study the effects of chemical treatments (addition of gypsum, copper sulphate, calcium chloride, etc.), mechanical treatments (spading, discing, removing topsoil, etc.), management practices (depth of water in ponds, drying periods, desilting water, etc.),

addition of organic matter (alfalfa hay, cotton gin trash, fertilizers, grass mulches, etc.), and vegetative trials (growing various grasses or crops).

"Four years of test pond work indicates that the best treatment was the use of cotton gin trash which was wet for about thirty days after which it was allowed to dry. The infiltration rate after the drying period started out high and remained high. After five years the ponds treated with cotton gin trash still show a high infiltration rate. The next best treatment was the use of Bermuda grass as a crop.

"In 1947 a laboratory was established at Bakersfield to study the soils and biological aspects of this problem to determine the reason for the results of the cotton gin trash treatment and to find a synthetic amendment which would act like the cotton gin trash. Other organic materials such as alfalfa, redwood sawdust, and potato vines are being studied. Some substances in the cotton gin trash seem to cause an aggregation of the soil which increases infiltration rates...The final answers are not yet available. Continued research, however, will develop techniques and establish practices which will permit successful recharging of ground-water aquifers."

Thus there are different methods in use to prevent decrease of permeability due to silting or changes in soil structure in recharge basins, or to maintain their permeability even in spite of silting. In our case, the best methods seem to be:

<u>a</u> settling of the greater part of the silt in one or more still pools

<u>b</u> installation of a shallow recharge basin (or basins) using cotton gin trash for maintainance of permeability

Very turbid storm waters are not allowed to enter the recharge basins at all - in many places, they are guided past their entrances, e.g., at East Orange, N.J. (R.M. Roper, 1939, page 178). Of course, such a procedure is possible only when there is plenty of surface water - more than can be recharged into the ground.

The factor (b) (necessity of a discharge well, page 66) is a serious matter in our case, because, unless a discharge well (a new town-supply well!) lowers the piezometric level of the artesian horizon which, according to different reports, is from 1½ to 14½ feet below the surface, only a very small volume can be recharged: viz., the volume of the pore

spaces in the pit or shafts from their top down to the piezometric surface. Thus a new producing well is necessary near the recharge installation. Some producing wells of the Duhernal and Runyon area, N.J., are placed directly in the recharge ditches or basins. The ground is sandy there, and thus the recharged surface-water becomes sufficiently filtered even in the short distance down to the well screen. No bacteriological contamination is reported from the wells of the Indiana Ordinance Works, located 200-500 feet from the river, though they receive water from gravel (R.G. Kazmann, 1948, pages 406-412). As the aquifer is gravel or gravelly sand in our area, it is advisable to locate the producing well at least 200 feet down stream from the recharge basin or shafts. Repeated bacteriological tests should be required before the well is accepted for town supply.

The factor (c) (amount of water available for recharge, page 66) does not involve any difficulties, because of the relatively humid climate of our area.

The area from which the recharge basins (installed below the junction of Catfish Creek and Springfield Creek) may receive run-off water is about 30½ square miles or 19,500 acres in extent.

The average yearly precipitation at Aylmer is 35.35 inches (based upon observations of seven years), with a minimum of 29.19 inches and a maximum of 42.28 inches. Similar yearly precipitation is observed in other nearby stations: 34.86 inches at St. Thomas (average of twenty-three years) and 33.79 inches at Delhi (average of ten years) (C.L. Merrill, 1950).

No actual data of run-off in the Aylmer-Brownsville area are available. According to L.F. Chapman and D.F. Putnam, 1951, page 106, run-off of the Thames River near London is equivalent to 12.2-12.7 inches of rainfall, or about one-third of the annual precipitation. The run-off of the

Grand River and its tributaries is similar (ibid., pages 109-113), equivalent to 11-15 inches of rainfall. As the climatic conditions and the soil of the Aylmer-Brownsville area are similar to those on the Thames and on the Grand Rivers, the same relative amount of run-off may be assumed for a rough calculation. That gives the volume of run-off water equal to about 20,000 acre feet or over 5,000 million gallons. That is more than 21 times the annual consumption of water of the town of Aylmer. As the precipitation is approximately uniformly distributed through the year, though with minor variations from year to year, and with relatively high flood waters in the spring, it would be possible to let the turbid flood water flow past the recharge basins without any great fear that there will be lack of water. It may even be sufficient to use the Catfish Creek without the Springfield Creek as a source of recharge, if it is shown by systematic observations and measurements that the Springfield Creek carries more silt than Catfish Creek and that Catfish Creek alone provides a sufficient quantity of water.

In our discussion of the most suitable type of recharge installation, both pits and shafts filled with gravel have been suggested.

Among other kinds of recharge installation, which may be used for the geological structure found at Aylmer, open wells or shafts may be mentioned. They are used relatively successfully for returning clean ground water to the ground after it has been used for cooling or air-conditioning, e.g., on Long Island, N.Y. (A.H. Johnson, 1948; M.L. Brashears, Jr., 1946; J.H. Sanford, 1938). However, the clogging and silting of such recharge wells is often reported, though the water used was clean. M.L. Brashears, Jr., gives the following explanation (1946, page 510):

> "Even though the amount of silt in the water is small, the aggregate may constitute a large quantity. For example, if the water pumped from a supply well on Long Island, which is operated about 1,000 hours during the cooling season at the rate of 500 gallons per minute, contained only one ounce of silt in every 100 gallons, it would carry nearly 10 tons of silt into the recharge wells."

Even more silt and other material (iron hydroxide, calcite, etc.) will accumulate around the screens of recharge wells, if surface waters are used for recharge, and there may also be growth of algae and bacteria around the screens.

Another cause of the silting of recharge wells and open pits is the washing of their sides by turbulent water, as has been observed in Lyttle Creek, California (A.T. Michelson and D.C. Muckel, 1937, pages 75-77), where 80 feet of loose material accumulated in a shaft with a diameter of 4 to 6 feet, which was lagged with redwood planks, spaced 1½ feet apart.

There have been a few successful short-time experiments with recharge wells reported at Los Angeles (up to three months), using surface water (D.A. Lane, 1934, page 525), while other wells (ibid., page 524) have been clogged in the same time ("a few days").

Thus G.D. Clyde (1950, page 5), concludes that

> "Recharging through wells or shafts has been tried with little success. To use pump wells for recharging during the non-pumping season has been found in many cases to be detrimental to the well. This is due to silting up of the aquifer around the well casing. Even relatively clear water will in time seal up the porous material next to the well screen. Recharging through well screens accelerates the incrustation of the well screens. Biological activity may form jelly-like substances which seal off the pores."

> "Recharge wells supplied with water from surface streams will be effective only provided the surface water is filtered to remove suspended matter, including not only silt and clay, but also organic matter, which may grow and tend to clog well screens. The cost of such filtration, plus the cost of cleaning and otherwise maintaining the recharge wells, would be considerable." (D.G. Thompson, 1942, page 64).

Recharge through wells, even using surface water, may be successful for a longer time in geological conditions different from those in our area: e.g., in cavernous limestone in Florida (O.E. Meinzer, 1946, page 197).

The conclusion of the foregoing discussion is that the most suitable installation for ground-water recharge north-east of Aylmer, using creek water, would be either pits or a set of large-diameter drill-holes, in either case filled with gravel. Creek water, before entering the recharge basin (or basins) must be cleared of silt in one or two still-pools. Cotton gin trash should be used in the recharge basin to maintain its permeability in case silt accumulates. In order to avoid admitting highly turbid flood waters to the recharge basins, the main flow of the creek must not go through them. A discharge well should be operated near the recharge basin, but not nearer than 200 feet. It will create a drawdown in the piezometric surface which is necessary for storage of the recharged water. The size of the recharge pit or the number of recharge shafts will depend upon the permeability of the gravel used for their filling, the amount of drawdown of the piezometric surface, and the amount of water which it is intended to recharge. A theoretical calculation, based upon observations at Azusa, California, would require a pit 2/3 acre in extent (or a set of shafts with the same cross-section or surface of percolation) for recharging the same amount of water that is consumed by the town of Aylmer at the present time. If the percolation rate is higher, a smaller pit will be sufficient.

CHAPTER 10

SUMMARY

The north-eastern part of the Catfish Creek Watershed, the Aylmer-Brownsville area, is a wide triangular depression with two recessional moraines, the Norwich moraine and the Tillsonburg moraine, along its sides.

The thickness of pleistocene deposits varies from 160 feet (in the north-east part of the depression) up to about 325 feet. The thickness increases generally towards the south, and is the greatest along the Tillsonburg moraine. The bedrock surface is also dipping to the south. It has some valley-like depressions, which are not reflected on the earth's surface and which increase the thickness of the pleistocene deposits above them.

Pleistocene deposits consist of three main horizons in the Aylmer-Brownsville area:

(a) the upper clayey till with a cover of younger lacustrine and deltaic deposits;

(b) the sandy and gravelly younger subhorizon of the lower till;

(c) the older subhorizon of the lower till, not exposed in creek cuts. Structural studies indicate existence of a buried shoreline, possibly of the last interglacial Lake Erie near Aylmer.

A brief review of the historical development of the area during the pleistocene time and the main types of deposits can be found in the stratigraphical table of pleistocene deposits (page 35A). Studies of varved clays indicate that the time elapsed between the ice retreat from the Norwich moraine and the formation of the Tillsonburg moraine has been about twenty years.

At least five ground-water horizons are found in the area, four of them showing artesian pressure. The non-artesian, upper ground water is in the late-glacial sands on top of the upper till. Among the artesian horizons two are relatively important:

(1) the so-called first artesian horizon in the younger subhorizon of the lower till with a steep drop down the buried interglacial lakeshore, and

(2) the second artesian horizon along the top of the older subhorizon of the lower till in the area above the buried shoreline.

A third one is along the bedrock surface, and it has a tendency to become sulphurous. Even higher fresh-water horizons, e.g. the first one, tend to become sulphurous if their artesian pressure is decreased due to heavy pumping, enabling the sulphurous water to invade them.

The Aylmer Town Wells and the Airport Well are discussed more in detail. It is suggested to exploit the second artesian horizon for high-production wells, or to combine ground-water recharge with discharge from the first horizon. The problem of ground-water recharge in an artesian horizon is discussed; and pits, filled with gravel, combined with still-pools, are suggested for the area north-east of Aylmer.

CATFISH WATERSHED
GROUND WATER STUDIES

LEGEND

AREA OF PROPOSED GROUND WATER INSTALLATIONS

MORAINES

LARGE WELLS

PROFILE SECTIONS

HIGHEST SHORE LINES OF GLACIAL LAKES: MAUMEE, WHITTLESEY, ARKONA

SURFACE CONTOURS (INTERVAL 25FT.) 775

SCALE : MILES

1 ¾ ½ ¼ 0 1 2

ONTARIO DEPARTMENT OF PLANNING AND DEVELOPMENT
SURVEYED 1960

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FORESTRY

FORESTRY

CHAPTER 1

THE FOREST

1. At the Time of Settlement

Little remains of the original forest of Southern Ontario, particularly in such areas as the Catfish Watershed where the land is mostly of high agricultural value, but the vestiges which have survived and the works of contemporary writers help in reconstructing the scene. From these it is possible to see the reasons for the animosity of the pioneers to this great, oppressive and fearsome thing which overlay the good earth and must be hacked, slashed, beaten down and burned if they themselves were to survive.

Anna Jameson[1], travelling by stage coach from Toronto to Detroit in 1837, gives the following picture of the forest between Brantford and Woodstock just north of the Catfish Watershed as seen through the eyes of a visiting Englishwoman:

> "No one who has a single atom of imagination can travel through these forest roads of Canada without being strongly impressed and excited. The seemingly interminable line of trees before you; the boundless wilderness around; the mysterious depths amid the multitudinous foliage where foot of man hath never penetrated, and which partial gleams of the noon-tide sun, now seen, now lost, lit up with a changeful, magical beauty ...the solitude in which we proceeded mile after mile, no human being, no human dwelling within sight."

Later on she gives a vivid sketch of the typical clearing:

> "The aspect of these was almost uniform, presenting an opening of felled trees of about one acre or two...great heaps of timber trees and brushwood laid together and burning; a couple of oxen dragging along another enormous trunk to add to the pile. These were the general features of the picture framed, as it were, by the mysterious woods."

At one place she stops and chats to a settler who has one hundred and fifty acres of land of which he has

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1. Anna Jameson. Winter Studies and Summer Rambles in Canada. 1837.

cleared five to six acres in the past five years. He tells her, "You may swing the axe here from morning to night for a week before you let the daylight in upon you".

The settler's aim was to eliminate the trees, for they interfered with all his works of farming, road construction and town-site development and he attacked them with every means in his power. Anna Jameson describes a ghastly sight on the road between Hamilton and Brantford:

> "I remember a stretch of about three miles on this road, bordered entirely on each side by dead trees, which had been artificially blasted by fire or by girdling",

and remembering the park-like estates of her own land expresses her feelings thus:

> "I cannot look with indifference, far less share the Canadian's exultation when these huge oaks, these umbrageous elms, and stately pines, are lying prostrate, lopped of all their honours, and piled in heaps with the brushwood to be fired, - or burned down to a charred and blackened fragment - or standing, leafless, seared, ghastly having been girdled and left to perish".

Not all the forest was dense and dark, however; the Indians originally cultivated the bottom lands, and Mrs. Jameson also describes more open types of forest:

> "Oxford, or rather Ingersoll, where we stopped to dine and rest previous to plunging into an extensive pine forest called the 'Pine Woods'... The forest land through which I had passed, was principally covered with <u>hard timber</u> as oak, walnut, elm, basswood. We were now in a forest of pines, rising dark and monotonous on either side. These seven miles of pine forest we traversed in three hours and a half; then succeeded some miles of open, flat country called the oak plains and so called because covered with thickets and groups of oak dispersed with park-like and beautiful effect..."

This pine forest extended more or less continuously from Ingersoll down Otter Creek to Port Burwell but lay east of the Catfish Watershed. It, along with oak, was the basis of the great lumber trade which later developed here.

The woods of Oxford County were described in

1876[1] as follows:

> "In its primitive state the towering pines of Blenheim had fellowship in those of Norwich and Dereham (Townships) while the maple leaf was seen in richest luxuriance in the Oxfords, Zorra and Nissouri (Townships)."

W. H. Smith travelled across the Catfish Watershed in 1851 and states:

> "From Sandytown (now Staffordville) to St. Thomas the timber is hardwood intermixed occasionally with a little pine; the soil is rich clay alternately with sandy loam."

These early descriptions indicate that the original forest was predominantly hardwood with a sugar maple - beech cover type which, with associated southern hardwood species, occupied the best soils. Soft maple and elm occupied the poorly drained soils. Oak, in open park-like groupings, held possession of the sand plain while scattered white pine trees towered above the hardwood forests and grew in stands on well drained loam soils. White cedar and mixed woods of white cedar, hemlock, white pine, soft maple and yellow birch grew on the very limited muck areas.

The suitability of the greater part of the soil of the Catfish Watershed for cultivation and the inimicable attitude of the settlers to the forest led to very rapid depletion of the woods, and the swing of the pendulum carried the clearing of them past the bounds of economic necessity and past the point which would have left the minimum area of woodland required to protect the natural water-storage areas of the watershed.

2. <u>Since Settlement</u>

The attitude of the early settlers to the forest was completely hostile, as has been shown, which feeling was very natural because the forest was undoubtedly the greatest obstacle to the economic development of the land.

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1. Topographical and Historical Atlas of the County of Oxford. 1876.
2. W. H. Smith. Canada: Past, Present and Future, 1851.

Part of the animosity may have been engendered, tco, by the fact that, not so many years previously, the forest had sheltered the native Indians who had harassed the homesteads farther east. This ingrained antagonism became a sort of vendetta which has only begun to disappear in comparatively recent years.

When a new area was opened for settlement the best land was naturally taken first and the rough and swampy areas were avoided. Land was usually cleared first along the fronts of the farms and the woodland cut farther and farther back toward the end of the farm which lay farthest from the road. This was done, in many cases, without reference to the quality of the soil except where it was swampy, with the result that the majority of woodlots now lie at the back of the farms between the concessions.

The land bordering swamps was eventually taken up, the swamps were partially drained so that the edges became dry enough for partial cultivation, and the forest was pushed back so that today the centres of the swamps form the nuclei of all the larger patches of woodland in the Catfish Watershed. These swamps also form the largest natural surface water-storage areas, and in many cases are the sources of headwater streams. Trees will grow here in most cases and are probably the most profitable crop which can be raised, especially since they perform the additional function of protecting the source areas from too rapid run-off.

Although settlement did not begin until the early part of the nineteenth century and the forest was almost unbroken along Governor's Road for miles west of Ingersoll as late as 1837, so rapid was the reductionn that by 1860 the forests of Elgin and Oxford Counties were depleted by more than 60 per cent, by 1910 by 90 per cent, and by 1940 the Census of Canada showed woodland figures for

the counties embodying the Catfish Watershed to be: Elgin 9 per cent and Oxford 7 per cent.

The accompanying table shows the rate at which the forests were cut rather than the actual areas of woodland remaining at the dates shown, because the definition of woodland varies with the individual person. For instance, a farmer may consider cut-over land which is used as pasture to be pasture, while the forester may consider similar cut-over land, on which the reproduction is good, as potential woodland and records it as such. The actual measurement of woodland in the Catfish Watershed made in 1950 shows a total of 8,332 acres or 8.5 per cent.

WOODLAND IN PER CENT AND ACRES

ON OCCUPIED FARM LAND

CENSUS OF CANADA FIGURES

County	Township	Township Area (Acres)	1850		1860		1890		1910		1920		1931		1941	
			%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres	%	Acres
Elgin	Bayham	56,995	44	25,289	52	29,520	24	13,841	11	6,171	12	7,139	15	8,337	12	6,816
	Dorchester S.	30,532	39	11,840	19	5,877	19	5,859	7	2,090	7	2,163	6	1,730	6	1,703
	Malahide	62,763	32	20,290	40	24,782	22	13,984	10	6,428	10	6,596	9	5,821	8	4,968
	Yarmouth	68,617	47	32,372	35	23,826	17	11,769	8	5,562	7	5,130	7	4,876	7	5,050
Oxford	Dereham	63,851	42	26,816	41	26,265	19	12,205	8	5,233	9	5,741	7	4,737	7	4,204

Figures for 1870, 1880 and 1900 not available

CHAPTER 2

FOREST PRODUCTS

The forests of the Catfish Watershed were largely hardwood; comparatively little of the timber was exported to Britain though large quantities went to the United States. Softwood timber was never abundant and most of it was required for local use[1]; also the building of ships for the lakes trade soon became a thriving business and this absorbed a great deal of timber. For these reasons the masting and square timber trades were never as large as in many other parts of Ontario, though very considerable quantities of oak were exported as square timber.

1. Early Policy

Previous to 1826 the only persons authorized to cut timber on the public lands were the contractors for the Royal Navy, or those holding licences from them, and there was great infringement of the regulations and much illicit trade. But in this year the first steps toward making the forest resources a source of revenue to the Province and "so securing to the public a share of the wealth drawn from the public domain" led to co-operation among the officials and the termination of the contractor's monopoly. The inauguration of a system under which anyone was at liberty to cut timber on the ungranted lands of the Ottawa lumber region on payment of a fixed scale of rates to the Crown overcame in large part the annoyance of the people and authorities in the colony against the export of the sound

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1. "In the London and Western Districts (of Upper Canada) ... there are not more pine and cedars than suffice for building material and fencing timber for home consumption. Indeed there are several townships in the Western District entirely destitute of pine timber ... a circumstance ... attended with many serious inconveniences." E. A. Talbot. Five Years' Residence in Canada. 1824.

Canadian timber for the British navy.

2. Masting

The selection of mast timber was made by government agents who went through the forest blazing with a broad arrow - the mark of the British Government. As late as 1827, when Peter Robinson was appointed Surveyor-General of His Majesty's woods and forests in the province of Upper Canada, he was instructed "to make a survey of the districts where there may be any considerable growth of masting and other timber fit for the use of His Majesty's navy".

The mast and spar export to Britain was thriving in the thirties and forties and it was continuad intermittently as late as 1855. The British trade dropped off noticeably after 1854 and this may be attributed to the Reciprocity Treaty with the United States in that year, "securing the free exchange of the natural products between Canada and the United States, including timber and lumber of all kinds, round, hewed, and sawed, manufactured in whole or in part", and the building of railway connections with the United States border cities.

3. Square Timber

The square timber trade commenced, no doubt, somewhat later than the mast trade and was carried on simultaneously with it from the thirties.

Square timber was obtained by selecting large trees, mostly white pine, and squaring the best part into one long stick. On the Catfish Watershed far more hardwood and tamarack than pine was taken out as square timber. In the earliest days of the industry the timbers were squared on all four sides to a fine "proud edge", but later, when the best timber had been cut, they were squared with a rounded shoulder or "wane" and were known as "waney timber". Such methods, of course, were wasteful since the finest

FOREST PRODUCTS OF FARMS - CENSUS OF CANADA FIGURES - ELGIN COUNTY

Products	Species	Unit	1870	1880	1890	1900	1910	1920	1930	1940
Pulpwood		Cord			255	12				
Tanbark		"	275	37	115	16				
Lathwood		"	1,600	243	20					
Masts & Spars		Number	8	299	98					
Staves		M	894	1,136	51	1,219	255			
Fence Rails		Number						518	1,828	
Fence Posts		"			60,504	25,460	6,570	10,990	11,258	
Poles		"				58	200		250	
Rwy. Ties		"			24,566	550				
Sq. Timber	White Pine	Cu. Ft.	2,669	134,294	36,028	2,893	15,075			
	Red Pine	"		31,525	500					
	Ash	"				8,474	6,800			
	Oak	"	70,745	265,516	24,522	8,722	4,400			
	Tamarack	"	136,938	7,330	100					
	Birch/Maple	"	9,100	136,560	125	7,630	58,685			
	Elm	"	61,872	64,127	146,776	15,271	4,563			
	Walnut	"	26,533	4,994	5,400					
	Butternut	"	4,237	6,569	1,240					
	Hickory	"	5,334	48,025	61,947					
	Others	"	82,981	737,857	53,598	14,994	7,478			
Logs	Pine	Number	14,792	37,280	21,571	1,067 M	377 M			
	Hemlock	"				34 M	24 M			
	Hickory					163 M	14 M			
	Oak					487 M	70 M			
	Spruce					21 M				
	Elm					7,082 M	670 M			
	Others	Number	50,234	192,916	247,255	5,764	2,500 M	63,404 M	668 M	
Firewood		Cord	117,727	149,952	145,396	171,028	89,613	81,620	59,004	48,352
Other Products		Value $						5,635	1,306	16,388

M - 1,000 feet board measure

FOREST PRODUCTS OF FARMS - CENSUS OF CANADA FIGURES - OXFORD COUNTY

Product	Species	Unit	1870	1880	1890	1900	1910	1920	1930	1940
Tanbark		Cord	586	444	106	79				
Lathwood		"	193	37	84					
Masts & Spars		Number		226	8	20	9			
Staves		M	634	1,704	81	1,810	899			
Fence Rails		Number						4,130	1,920	
Fence Posts		"			56,309	32,304	10,542	12,815	14,479	
Poles		"			51	313	195	15	516	
Rwy. Ties		"			3,005	25	50			
Sq. Timber	White Pine	Cu. Ft.	13,264	12,791	29,601	3,022	4,000			
	Red Pine	"	614	1,418	800					
	Ash	"				2,824	800			
	Oak	"	41,950	59,921	5,345	4,368	1,550			
	Tamarack	"	52,525	38,291	19,895					
	Birch/Maple	"	3,545	29,663	8,427	2,624	4,718			
	Elm	"	166,196	78,025	46,522	98,457	25,382			
	Walnut	"	300		300					
	Butternut	"	1,436	1,000	4,850					
	Hickory	"	7,830	5,472	11,000					
	Others	"	94,557	116,168	40,337	6,881	4,000			
Logs, Softwood	Pine	Number	35,788	105,020	55,762	331 M	178 M			
	Hemlock	"				197 M	26 M			
	Hickory					13 M				
	Oak					164 M	51 M			
	Spruce					57 M				
	Elm					2,134 M	1,397 M			
	Others	Number	13,157	164,538	289,767	1,540 M	1,184 M	17,770 M	641 M	
Firewood		Cord	142,282	165,169	137,571	128,640	61,311	73,816	49,203	5,542
Other Products		Value $					96	100	731	14,315

M - 1,000 feet board measure

grained wood was sacrificed in the operation, but this was the type of material called for by the British market.

> "Often only one tree in a thousand would yield a finished 'stick' (so was the heavy square timber nonchalantly called in the trade) fit for export. A good stand might yield thirty or forty trees an acre for over the whole area allowance had to be made for 'wants') - the non-bearing patches of swamp, burn, etc. To-day a whole township or limit (in Northern Ontario) may not have one good square stick of the quality of the square timber of another day."[1]

The timbers were transported by the river, by teams or by railway to the lake and were built into huge rafts on which the lumberjacks built shanties and lived during the trip down to the timber coves at Quebec.

4. Saw Material

From 1800 on the cutting of timber had been one of the most important domestic businesses in most parts of Southern Ontario, and a very considerable business was carried on.

The great lumber industry in this part of the country centred on Port Burwell which was the principal shipping port to Oswego, Buffalo, Cleveland and Huron. This was due to the abundance of pine on Otter Creek and the fact that this stream was navigable up to Vienna. Much of the timber on the Catfish Watershed must have been shipped from Port Burwell.

In order to convert logs into boards the first method used was pit-sawing. This was sometimes done on the bank of the river, as such procedure saved the necessity of digging a pit.

The more usual methods of pit sawing appear to have been the digging of a pit or building of a platform

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1. Gillies Bros. Ltd. 1942. A Hundred Years A-Fellin', 1842 - 1942.

with a simple but firm and strongly constructed framework. In either case the framework was made the right height for one man to stand underneath, while the other man stood above on the platform or astride the log. This hard method of sawing timber was laborious and twenty-five boards were a heavy day's work for two men; the boards were nearly always one inch thick, with planks two inches, and the occasional flooring one and a half inches in thickness.

The first power saws were a direct development of the manually operated pit saw. These were called frame, upright or muley saws and consisted of a saw set vertically in a wooden frame and moved up and down by means of a crank connected to the shaft of the water wheel.

> "Wherever a settlement is formed in America a sawmill is very soon after, if not at the same time, erected. The number of sawmills in the British colonies are inconceivable to those who are not familiarized to the rising settlements of new countries.
>
> "A sawmill is in fact a most important establishment. It not only forms a nucleus or centre to a settlement, but a first-rate sawmill, with two frames, will give employment to four first-rate, four second-rate and two third-rate sawyers, besides a measurer, a blacksmith and from thirty to forty men to prepare the timber required and for other requisite work connected with the establishment; twenty oxen and two horses are also necessary for hauling the timber required to streams and to other places. The boards, deals and scantlings sawed at these mills, excepting such as are required for the use of the neighbouring settlers, are rafted down the river for shipping. As fresh waters change the colour of the deals from their fresh whit to a dark gray and, in the eyes of prejudice, depreciate their value, it becomes an object, but one that can only be attended to occasionally to carry them down in bateaux, scows or on timber rafts."[1]

A study of the Census of Canada returns of forest products of farms for the counties of the watershed given in the table reveals the various trends and changes in the lumber industry fairly clearly.

From 1870 to 1890 much of the timber was squared and measured in cubic feet. In 1870 other products listed were firewood, staves, lathwood, tanbark, and masts and spars. In 1880 the peak production of nearly all items

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1. John McGregor, 1833. British America, Vol. II.

was reached and squared elm alone in Oxford County and squared oak in Elgin ran to almost 167,000 and 266,000 cubic feet respectively. In 1890 fence posts and telephone poles were added to the list of products, as were railway ties. In the census years of 1900 and 1910 square timber was still recorded in cubic feet and logs were measured in board feet; staves, lathwood, masts and spars and tanbark disappeared from production.

In 1920 no square timber is shown and logs are not even separated by species. The returns of the latest census covering the year 1940 name only one forest product and the rest are all listed together as others valued at so many dollars. The one product which has persisted throughout the records is firewood which in Elgin County has dropped from a peak of 171,028 cords in 1900 to 48,352 cords in 1940.

One or two interesting observations with regard to individual species may also be made. Tamarack was listed regularly until 1890, exceeding all other species cut in Elgin County in 1870; after 1890 it no longer appears, due to the depredations of the larch saw-fly which almost wiped it out at this time. The returns show that some black walnut and hickory were cut in both counties each year until 1880. White pine was, of course, the species most sought after, though not much existed in the counties of the watershed, and next to it red pine of which a little was present in both counties. In 1870 and 1880 elm and oak were the main species which were squared, but ash, birch, and maple were also made into square timber.

5. <u>Shingle-Making</u>

In the history of roofing used on the Catfish Watershed it is found that the first covering for human habitation on the river was the Indian elm-bark lashed roof. The first type of roof used by the early

settlers was made of "scoops" which were flattened logs, usually cedar, six inches thick with one face scooped out to a depth of one to one and a half inches. These ran from the peak of the roof to the eaves, being placed alternately so that one scoop had the scoop side up and the next one the scoop side down, the edges overlapping the two scoops below.

The second type of covering was a rude type of shingle called a "shake". These were made with an axe or frow and were cut from pine or cedar three or more feet in length. Although not shaped they were a great improvement over the early types of covering.

Very early in the history of settlement, however, hand-made shingles were introduced. The shingle-maker would saw the logs into short lengths or bolts and split them with a frow to the right thickness. The shingle was then fastened by one end in a device called a shingle horse and by means of a heavy drawknife the shingle was tapered to an edge. This method was rapid and it has been said that a good shingle-maker would turn out from eighty to a hundred of these hand-made shingles an hour.

Up to the seventies and even later the shingle-maker continued to use drawknife and frow, but gradually in the seventies the generation of craftsmen died out and the shingle mill, where shingles were sawn, became the general source of supply.

6. Fuel and Ties

From the earliest days of settlement on the Catfish to 1850, wood was the sole source of fuel supply. All species were used for this purpose, including beech and maple - though these were furniture woods as well. With the inception of the railway and steam-driven factories, the forests of the area were ruthlessly cut to feed industry.

In the very early days of the steamship, 1832, the Honourable Adam Fergusson writes: "Wood is furnished

upon the St. Lawrence for one dollar, or five shillings per cord while upon the Hudson it now costs three times as much. A man may prepare two cords a day, but it is severe work, and the price, which is one dollar per cord, will do little more than compensate maintenance and labour - and an ordinary steamboat consumes fifty or sixty cords or about 7,000 cubic feet each trip (from Montreal to Quebec)." The price of cordwood in 1825 was quoted at $2 a cord.

With the completion of the Great Western between Toronto and London in 1853, locomotive requirements took large quantities of the best body hardwood, chiefly beech and maple. "Coal at that time was not to be had and the result was that hardwood was gradually becoming of some value. For cordwood the settlers usually realized from $2.50 up to $3.00 per cord, delivered at the various stations along the railway line. Railway facilities also stimulated the lumber industry."[1]

7. Road Materials and Fencing

In the early days the making of corduroy roads furnished another important wood use. The Indian trails had followed the ridges and natural conformation of the country, but when the "T-square" roads had been laid out in government offices they followed the arbitrary lot and concession lines regardless of natural contours. Many of these roads were built through swamps and in these places corduroy construction was used. Many corduroy bridges and culverts were also placed over the river and its tributary streams.

The building of plank roads - a form of highway in which the planks were laid crosswise and side by side - was done in several parts of the Province. Plank roads alternating with gravel stretches connected the main centres

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1. E. W. B. Snider, Waterloo County Forests and Primitive Economics. 6th Annual Report of the Waterloo Historical Society, 1918.

in the southern part of the watershed in 1851. The roads from St. Thomas to Staffordville via Aylmer were one of these and the road to Port Stanley was planked all the way from London.

Much wood was also used for fencing and for this cedar from the swamps was most common. The troublesome pine stump also was used for this purpose in many parts of the Province, although in very early times it seems that it was left in the field. Around 1900 the wire fence came into use generally and thereafter a fence post industry was developed. These were cut as a rule to a standard length of eight feet, while the diameter varied greatly.

8. Woodworking and Planing Mills

W. H . Smith[1] lists a veneering mill in Malahide Township producing 50,000 feet of veneer a year.

The extensive hardwood forests which formerly existed over the greater part of the region were the reason for the large number of wood-using industries which were established, some of which are still doing a considerable trade although much of their raw material is now imported.

During the early years of settlement in the rural districts and communities, house trim for exterior and interior use was made by the same man who constructed the frame of the house. The custom up to the fifties at least was for the carpenter to board with the family the winter before the new frame house was to be built and work all his timber into shape by hand, both for exterior and interior use.

The early carpenter also made door and window frames and all interior trim of the house by hand and for all these products pine was the usual type of timber chosen. It would seem that doorsteps were one of the very few things for which oak was used in house building, at least up to the sixties.

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1. W. H. Smith. Canada: Past, Present and Future. 1851

Generally, as time passed, the building trades became more differentiated and more craftsmen settled on the watershed.

After the appearance of the planing mill in the fifties the end of the hand-made door and window frame was foreshadowed and much of the general carpenter's work was taken over by the mill or factory. By the 1860's the planing mill business was well under way.

9. <u>Wooden Implements and Vehicles</u>

(a) <u>Early Tools</u>

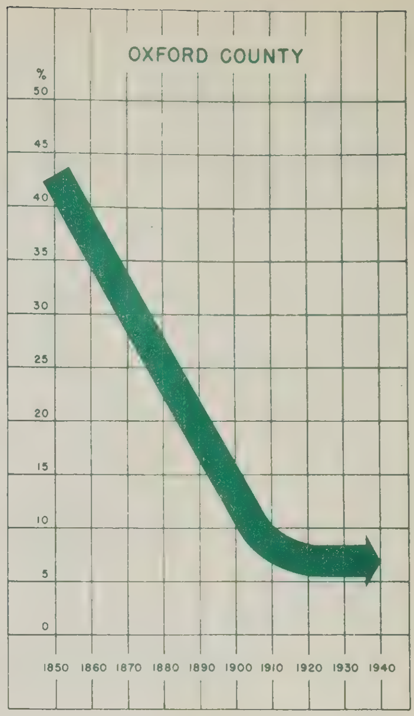
From the very early days hickory was preferred for the making of axe-helves or handles, while for beams or ox-yokes beech was used extensively and for the loop ironwood would have been selected. Spike handles were made of rock elm, white ash, hickory or ironwood; the beetle-head (a mallet used for pounding hemp and flax) was also made of ahs, elm, hickory or ironwood. The hardwoods growing on the watershed were used almost entirely for making handles of implements, whereas pine was preferred for all building operations when it could be obtained. In 1851 there was a rake factory in Malahide Township turning off 10,000 rakes a year.

(b) <u>Vehicles</u>

From early times the making of vehicles progressed and a carriage works operated for many years in Aylmer. Carts, wagons, sleighs and hay and woodracks were built by the farmers. In the building of carts and wagons, whiffletrees, wagon-tongues and binding poles were made of rock elm, white ash, hickory and ironwood, as were also sleigh-runners and hay and woodracks. Usually the wheels or runners of these conveyances were bound with iron, although the use of metal was limited in early days since the supply had to be imported by water.

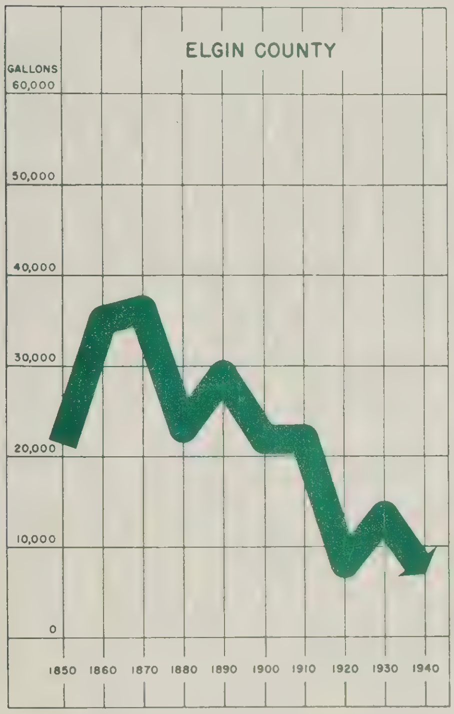
10. <u>Indirect Products and By-Products</u>

The three indirect products of greatest



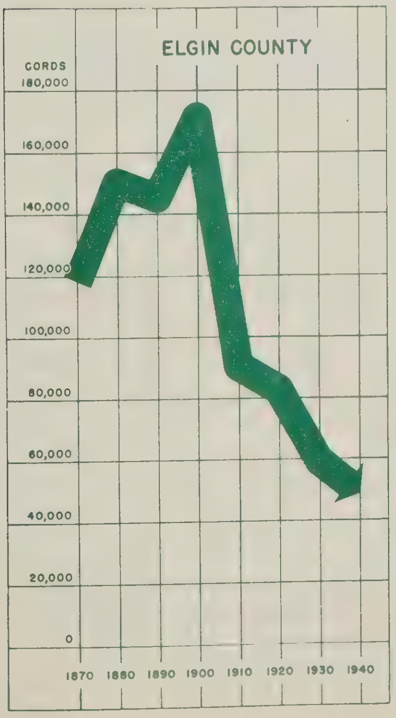
PER CENT WOODLAND ON OCCUPIED FARM LAND

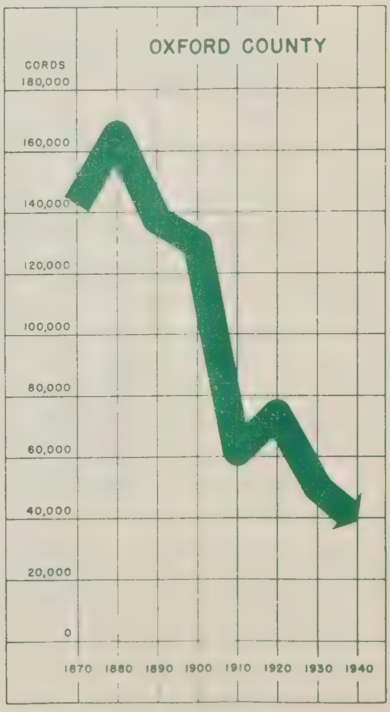
CENSUS OF CANADA FIGURES



MAPLE SYRUP PRODUCTION

CENSUS OF CANADA FIGURES





FUELWOOD PRODUCTION

CENSUS OF CANADA FIGURES

importance were potash, maple sugar and tanbark. Maple sugar furnished the staple sugar for the pioneers, cane sugar not having been procurable at that time; lye or potash was used domestically in making soft soap - almost the universal soap; tanbark was utilized by the shoemakers in dressing leather.

(a) Potash

The ashery played an important role in the drama of pioneering life and there was a large one in the town of Aylmer in 1851. Besides communal asheries the individual ash house and the ash barrel on a platform for leaching were a characteristic of each farm in the days before the soap factory.

> "Only from the sale of potash (exported to Great Britain and the United States for the dyeing of textiles) was there money for all other requisites. The potash was laboriously produced, men, women and children sharing in the heavy work. No less than 60 large maple trees were required for a barrel of 650 to 700 pounds of potash. The ashes of the burnt wood were leached in wedge-shaped wooden troughs and this liquid was then boiled down and cooled in huge vessels or coolers where the lye solidified. Two coolers would fill a barrel. If the settler marketed this on his own, 'toting it out' to the nearest buyer for ready cash, he might get only $8.50 to $9.00, but if he could wait and accept a down payment from the traders and shippers who teamed and hauled at a season of their own convenience, he might get $10 or $12 with a possible second payment after marketing it at Montreal where a barrel might bring $30, less of course commission, risk and portage costs. The need for this pitifully hard-won money led to clearing of more land than could be cropped and not infrequently to concealing for years the fact that the holding itself might not be profitable or capable of sustaining the settlers from the growth of its poor soil." 1

(b) Maple Sugar

The table shows the census figures for maple products in Elgin and Oxford Counties. It is interesting to note that up to 1910 production is all recorded as pounds of sugar; from 1910 on both pounds of sugar and gallons of syrup were shown, indicating the change from a pioneer

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1. Gillies Bros. Ltd. 1942. A Hundred Years A-Fellin', 1842 - 1942.

MAPLE SUGAR PRODUCTION

CENSUS OF CANADA FIGURES

County	1850	1860	1870	1880	1890	1900	1910		1920		1930		1940	
	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Gals.	Lbs.	Gals.	Lbs.	Gals.	Lbs.	Gals.
ELGIN	213,747	350,616	305,900	231,890	291,085	218,416	4,654	21,262	1,825	7,969	1,595	13,093	98	6,747
OXFORD	320,952	538,373	425,105	142,880	240,075	229,025	2,580	37,925	50	17,926	215	17,689	364	14,685

	Gals.	Gals.	Gals.	Gals.	Gals.	Gals.		Gals.		Gals.		Gals.		Gals.
ELGIN	21,375	35,062	30,590	23,189	29,108	21,846		21,727		8,141		13,252		6,757
OXFORD	32,095	53,837	42,510	14,288	24,007	22,902		38,183		17,931		17,710		14,721

In the second table pounds of sugar have been converted to their equivalents in gallons for purposes of comparison.

necessity to the modern luxury. For purposes of comparison the sugar figures have been converted to their syrup equivalents and from these shown in the second table it will be seen that production for Oxford County dropped steadily from the peak of nearly 54,000 gallons in 1860 to 14,721 in 1940, and a similar fall is shown in Elgin County.

CHAPTER 3

PRESENT WOODLAND CONDITIONS

The Catfish Watershed lies almost entirely within the Deciduous Forest Region[1], the boundary of which passes close to its northern limits. The Deciduous Forest Region enjoys a very moderate climate modified by being bounded by the Great Lakes Ontario, Erie and Huron. Though the forest in this Region consists primarily of beech and sugar maple together with basswood, red maple, red, white and bur oak, a large number of other species, many of small size, find their northern limit here. Among these are chestnut, tulip tree, pignut hickory; chinquapin, chestnut, black and pin oaks; black gum, blue ash, magnolia, papaw, Kentucky Coffee tree, red bud, red mulberry and sassafrass. In addition, within this region is the main distribution in Ontario of black walnut, sycamore, swamp white oak, and shagbark hickory, together with the more widely distributed butternut, bitternut hickory, rock elm, silver maple and blue beech. Coniferous species are poorly represented; very scattered hemlock occurs and on the lighter soils are small local areas of white pine.

1. Survey Methods

Each member of the Forestry party was provided with aerial photographs which were on a scale of 1,000 feet to the inch and each photograph covered an area of approximately 1,000 acres, usually a block lying between two adjacent concession roads and two adjacent side roads. Mapping was done in the field directly on the photographs.

Every area of woodland, brushland, marsh, swamp and rough land down to one acre in area was examined and notes made describing it. In the case of woodlots and plantations, detailed notes were made of their condition. Overgrazed woodlots and woodlots with very scattered trees which could be

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1. W.E.D. Halliday. A Forest Classification for Canada. 1937.

FOREST COVER TYPES

Township	No. of Woodlots	Area (Acres)	4	8	9	10	11	12	13	14	24	25	26	45	51	57	58	59	60	60A	88
Bayham	5	50							15									23	12		
Dereham	58	489	15		2			10	33	36						41	13	47	101	185	6
Malahide	300	3,936	59	11	74	22	76	291	18	374	14	9	172	13	6	1,137	285	255	602	439	13
S. Dorchester	157	1,177						42	216					5		153	23	384	68	286	
Yarmouth	287	2,680	25	63	3		15	201	107	277	11				27	666	281	370	178	409	41
Total	807	8,332	99	74	79	22	91	544	389	687	25	9	172	18	33	1,997	602	1,079	962	1,319	60
Per Cent			1.1	.9	1.0	.3	1.1	6.6	4.8	8.4	.3	.05	2.2	.2	.4	24.1	7.2	12.8	11.5	15.8	.7

restored were classified as woodland. In short, where doubt existed as to whether an area should be classified as woodland or not, woodland was given the benefit of the doubt.

All woodlots were grouped according to the following classification:

Diameter Breast High	Hardwood	Mixed Wood	Coniferous
Virgin	H-1	M-1	C-1
Over 18 inches	H-2	M-2	C-2
10 - 18 inches	H-3	M-3	C-3
4 - 10 inches	H-4	M-4	C-4
Under 4 inches	H-5	M-5	C-5

In this classification the term "hardwood" is used to denote all broad-leaved trees irrespective of whether the wood is physically hard or not. A hardwood type is one in which 80 per cent or more of the stand is composed of hardwood trees, a coniferous type is one in which 80 per cent of the stand is composed of coniferous trees and a mixed stand embraces all others.

Stands were also recorded according to forest cover types[1]. (Refer to the table, the description of forest cover types and the forestry map folded at the end of this report.)

The forestry map is on the scale of one mile to the inch and covers the whole of the Catfish Watershed. It shows all existing woodland, scrub land, and land recommended for acquisition by the Authority.

2. Forest Cover Types

A forest cover type may be either temporary or permanent; for example, the present stand may be aspen which has seeded in the area following fire. Aspen seed is

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1. Forest Cover Types of the Eastern United States. Report of the Committee on Forest Types, Society of American Foresters. 1940.

Very few areas of first-growth pine remain in Southern Ontario, but this corner of the woods near Springwater Pond is a good example of the tall straight timber which can be produced. Every effort should be made by the Authority to ensure the perpetuation and proper management of these woodlands, either by acquisition or agreement with the owners.

light like dandelion seed and is carried easily by the wind, thus it quickly covers large areas; also it is not exacting in its soil requirements and may be the only species which will grow under the soil conditions existing at the time. The fact of its growing and dropping its leaves on the ground gradually improves the condition of the soil so that more exacting species can grow. In addition its light shade frequently provides the correct light conditions for better species to get a start. As it is a short-lived tree, it will die early and the other species will dominate the area. This succession may be carried through two or more stages until the species best suited to the area or best able to maintain itself on the area takes over; this is called the forest type or climax type, as distinguished from the forest cover type which is the type occupying the ground at the present time. The most common forest type on the Catfish Watershed is sugar maple - beech.

No classification of forest cover types has been made in Canada for Southern Ontario, so the system used is a slightly modified form of that drawn up by the Society of American Foresters, which covers the whole of the eastern United States, consequently there are many types in their classification which do not enter Canada and this accounts for the gaps in the numerical listing of types occurring in the Catfish Watershed. The forest cover types of the Catfish Watershed may be listed as follows:

Number	Name
4	Aspen
8	White pine - red oak - white ash
9	White pine
10	White pine - hemlock
11	Hemlock
12	Sugar maple - beech - yellow birch
13	Sugar maple - basswood
14	Sugar maple
24	White cedar
25	Tamarack
26	Black ash - white elm - red maple
45	Bur oak
51	Red oak - basswood - white ash
57	Beech - sugar maple
58	Beech
59	Ash - hickory
60	Silver maple - white elm
60A	White elm
88	Willow

Type 4: Aspen

Aspen is a pioneer type coming in after fire or overgrazing. Though it avoids the wettest swamps it does grow on soils that are wet throughout a good part of the year, as well as on dry soils. Its associates may be white elm, paper birch, red cherry and balsam poplar, with occasionally large-toothed aspen and green ash. It forms only 1 per cent of the woodland of the watershed.

Type 8: White Pine - Red Oak - White Ash

This type occurs with red maple as the most common associate,though others which may be present are basswood, yellow birch, large-toothed aspen, sugar maple, beech, paper birch, black cherry and hemlock. Only 74 acres were found on the watershed.

Type 9: White Pine

White pine typically occurs on fresh, sandy loam upland but also on clay, in swampy areas and on loamy sand. On sandy soils it tends to be permanent but on heavier soils it is usually succeeded by the following types: sugar maple - beech, red oak - basswood - white ash, white pine - red oak - white ash, white pine - hemlock, sugar maple - basswood, or white oak.

Its associates on light soils are aspen, red maple, pin cherry and white oak; on heavier soils yellow birch, black cherry, white ash, red oak, sugar maple, basswood and hemlock. It was never very abundant on the watershed but now occupies only 79 acres of the wooded area, mostly in Malahide Township.

Type 10: White Pine - Hemlock

Associated with this type are many species but none is particularly characteristic. The principal ones are beech, sugar maple, basswood, red maple, yellow birch, black cherry, white ash, paper birch and red oak. It occurs on a range of sites from sand plains to heavy upland soils but favours cool locations such as the slopes of ravines. It constitutes only 22 acres of the woodland.

Type 11: Hemlock

This type occurs mostly in widely scattered bodies in cool locations, moist ravines and north slopes, frequently in the sugar maple - beech type. Its associates are beech, sugar maple, yellow birch, basswood, red maple, black cherry, white ash, white pine, paper birch and red oak. It makes up a little over 1 per cent of the remaining woodland of the Catfish Valley but was never abundant because of its preference for cool ravines, of which not many exist. It occurs mostly in Malahide Township.

Type 12: Sugar Maple - Beech - Yellow Birch

The associates of this type are basswood, red maple, hemlock, red oak, white ash, white pine, balsam fir, black cherry, paper birch and white elm. It occurs on well-drained loam soils and frequently gives place to beech - sugar maple type.

Type 13: Sugar Maple - Basswood

This is a fairly important type occurring on loamy, upland soils. Its associates are white elm, green ash, yellow birch, white pine and red oak with ironwood and blue beech as subordinates. It forms almost 5 per cent of the woodland of the watershed and the percentage is probably being continually reduced as basswood is a more sought-after species than sugar maple.

Type 14: Sugar Maple

This type undoubtedly originally covered a considerable part of the watershed, but since it occupied fertile, well-drained soil with good moisture much of it has been cleared for agriculture. A small proportion of other species such as yellow birch, white ash, red and white oak may be present. Today it covers over 8 per cent of the wooded area. Its area may have been increased in recent years by the removal of beech from Type 57.

Type 24: White Cedar

The associates of this type are tamarack, yellow birch, paper birch, black ash, red maple, white pine and hemlock. It occurs on sites of slow drainage which are not strongly acid, including the muck soils of the watershed, and is also present

on poor pasture land and bottomland. It is almost non-existent on the watershed, only 25 acres having been mapped.

Type 25: Tamarack

Tamarack occurs in muck swamps with little or no drainage, associated with white cedar and less commonly with red maple, black ash and aspen. The trees are small and have grown since the near-extinction of the species in the early part of the century. No extensive areas existed in the past and today it occurs on only 9 acres in Malahide Township.

Type 26: Black Ash - White Elm - Red Maple

This type occupies moist to wet soils in swamps, gullies and small depressions. Its associates are balsam poplar, yellow birch with sometimes white pine, tamarack, white cedar, basswood and bur oak. It comprises only 172 acres.

Type 45: Bur Oak

This is a very uncommon type in Ontario, the associates of which are red oak, white oak or black oak, and occurs on loamy slopes with south or south-west exposure. Only 18 acres are present on the Catfish Watershed.

Type 51: Red Oak - Basswood - White Ash

Associated with the type species are red maple, yellow birch, aspen, sugar maple, paper birch and beech on less well-drained soils. This is a relatively unimportant type, there being only 33 acres in the watershed.

Type 57: Beech - Sugar Maple

This is regarded as the typical association of the climax with red maple, white oak, red oak, hemlock, white elm, red elm, basswood, shagbark hickory and black cherry. This type was undoubtedly very extensive in the Catfish Watershed, but because it occupied the best land its area has been tremendously depleted. However, it still comprises over 24 per cent of the remaining woodland and is very generally distributed.

Type 58: Beech

This type also belongs to the Deciduous Forest Region and is, theoretically, the ultimate dominant of the climax, but it is almost invariably associated with sugar maple. Its other associates are red maple, red oak, white ash, white elm, red elm and bitternut hickory. Over 600 acres were mapped in the Catfish drainage area. A few areas were encountered where the type had originally been 57 and the sugar maple taken out for logs, leaving the inferior beech.

Type 59: Ash - Hickory

This type is not listed in the American classification but has been introduced because of its frequent occurrence in Southern Ontario. It is usually a residual type following cutting and grazing, often of Type 60: silver maple - white elm, though it may occur on any poorly drained, cut-over area. It is usually composed of a mixture of white, green or red ash and shagbark and bitternut hickory with bur oak, cottonwood, blue beech and ironwood as associates. It constitutes nearly 13 per cent of the woodland.

Type 60: Silver Maple - White Elm

This is a type of meltwater channels and poorly drained soils unsuitable for general farming unless completely and adequately underdrained; for this reason it and the similar white elm Type 60A have survived better than forest cover types on better drained land. Associated species are red maple, slippery elm, cottonwood, white, red and green ash, bur oak and bitternut hickory. This type represents 11.5 per cent of the woodland of the watershed and is the third most abundant type in the Catfish drainage area.

Type 60A: White Elm

Type 60A is very similar to the silver maple - white elm Type 60, but is found on drier sites as well as swamps and swales and its associated species are the same. It is not listed in the American classification but has been introduced here because of its frequent occurrence in Southern Ontario. It comprises nearly 16 per cent of the woodland,

WOODLAND CLASS

Township	No. of Woodlots	Area (Acres)	H2	H3	H4	H5	M3	M4	M5	C3	C4	C5
Bayham	5	50	5	15	30							
Dereham	58	489	98	119	181	91						
Malahide	300	3,936	386	1,075	1,759	557	42	45	33	7	25	7
S. Dorchester	157	1,177	65	244	542	326						
Yarmouth	287	2,680	132	621	1,276	504	6	123		3	13	2
Total	807	8,332	686	2,074	3,788	1,478	48	168	33	10	38	9
Per Cent			8.2	24.8	45.6	17.7	.6	2.0	.4	.1	.4	.1

WOODLOT CONDITIONS

Township	No. of Woodlots	Area (Acres)	Aged		Grazed		Fenced		Reproduction			
			Even	Uneven	Yes	No	Yes	No	A	B	C	D
Bayham	5	50	98	2	50			50			33	17
Dereham	58	489	362	127	375	114	116	373		44	140	305
Malahide	300	3,936	2,307	1,629	2,143	1,793	714	3,222	18	241	1,726	1,951
S. Dorchester	157	1,177	755	422	782	395	386	791	48	181	577	571
Yarmouth	287	2,680	1,261	1,419	1,765	915	561	2,119	60	268	1,509	843
Total	807	8,332	4,733	3,599	5,115	3,217	1,777	6,555	126	734	3,985	3,487
Per Cent			56.8	43.2	61.5	38.6	21.2	78.8	1.5	8.7	47.2	42.0

so that these two types together make up over 27 per cent of the total woods in the watershed.

Type 88: Willow

Several species are included in this type but the commonest is black willow. It occurs on wet sites, often on the margins of kettles, and includes only 60 acres on the Catfish Watershed.

The large map shows the distribution of all types throughout the watershed and from it the following observations may be made:

(a) Elm swamp types which covered only limited areas have survived pretty well throughout the watershed on level land.

(b) Cedar and tamarack swamps which were scattered along the valleys of streams have been severely overcut and pastured, and almost eliminated.

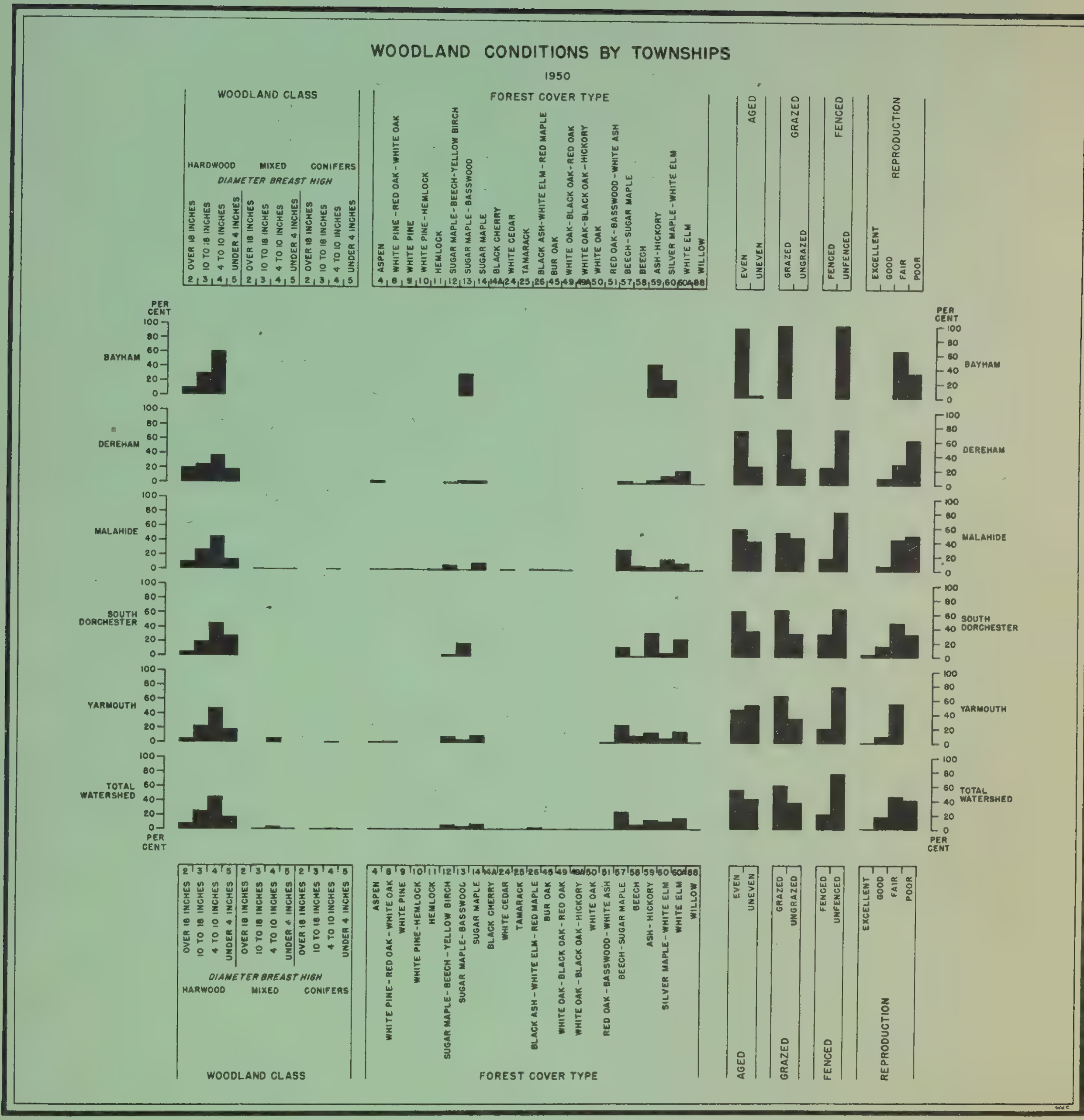
(c) Sugar maple types are still the most abundant and are found generally throughout the watershed.

(d) The chief residual type following cutting and pasturing is ash - hickory Type 59.

3. Present Conditions

The results of the forest surveys are summarized in the accompanying table.

Woodland within the watershed comprises 8,332 acres, which is 8.5 per cent of the total area of 97,843 acres. The total number of woodlots examined was 807, which includes many areas which are considered by their owners as constituting a single woodlot but which, because of the difference in types and age classes of certain sections, had to be considered in the field as separate units. Conversely, where property boundaries were not marked, woodland extending across two or more properties was sometimes considered as a unit because the type and age class remained constant throughout.


WOODLAND CONDITIONS BY TOWNSHIPS
1950
WOODLAND CLASS
HARDWOOD MIXED CONIFERS
DIAMETER BREAST HIGH
OVER 18 INCHES
10 TO 18 INCHES
4 TO 10 INCHES
UNDER 4 INCHES
FOREST COVER TYPE
ASPEN
WHITE PINE - RED OAK - WHITE OAK
WHITE PINE
WHITE PINE - HEMLOCK
HEMLOCK
SUGAR MAPLE - BEECH - YELLOW BIRCH
SUGAR MAPLE - BASSWOOD
SUGAR MAPLE
BLACK CHERRY
WHITE CEDAR
TAMARACK
BLACK ASH - WHITE ELM - RED MAPLE
BUR OAK
WHITE OAK - BLACK OAK - RED OAK
WHITE OAK - BLACK OAK - HICKORY
WHITE OAK
RED OAK - BASSWOOD - WHITE ASH
BEECH - SUGAR MAPLE
BEECH
ASH - HICKORY
SILVER MAPLE - WHITE ELM
WHITE ELM
WILLOW
AGED
EVEN
UNEVEN
GRAZED
GRAZED
UNGRAZED
FENCED
FENCED
UNFENCED
REPRODUCTION
EXCELLENT
GOOD
FAIR
POOR
PER CENT
BAYHAM
DEREHAM
MALAHIDE
SOUTH DORCHESTER
YARMOUTH
TOTAL WATERSHED

The conifers occurring in the watershed are white pine, hemlock, white cedar and tamarack. Red pine occurred in the original forest but no trees were found in the natural state at the time the survey was made. White pine is rare and scattered along the valleys of the streams. Hemlock is found mixed with hardwoods and white cedar and tamarack are present in the small swamps. There is no doubt that conifers formed a larger part of the woodland than they do today, but their numbers have been diminished because of the desirability of the lumber they furnish, and recurrent fires have destroyed them while more fire-resistant species such as oak have survived. The situation at the present time is that of the 8,332 acres of woodland, 96.4 per cent is classified as pure hardwoods, 3 per cent as mixed woods and 0.6 per cent as pure conifers. In the 96 per cent classified as hardwoods 8 per cent is over 18 inches in diameter at breast height, 25 per cent is 10 to 18 inches, 45 per cent is 4 to 10 inches and 18 per cent is young growth under 4 inches in diameter at breast height.

In the mixed wood classes, comprising 4 per cent of the woodland, less than 1 per cent is 10 to 18 inches in diameter at breast height, 2 per cent is 4 to 10 inches, while less than 1 per cent is young growth under 4 inches. In the coniferous woods 0.4 per cent is second growth, 4 to 10 inches at breast height, and 0.1 per cent is young growth under 4 inches.

For the whole area the percentage of even-aged stands is somewhat more than the uneven-aged, the figures being 57 per cent of the former and 43 per cent of the latter.

Grazing in farm woodlots is still fairly general, the percentage of grazed woodland being 61 per cent for the whole watershed. Grazing, as is well known, is detrimental to the proper development of any woodland area. The number of cattle and the size of the woodlot have a direct

relationship to the damage which is done. For example, a large woodlot is not as seriously affected by a few head of cattle as a small one, but on most farms the woodlot is small and is seriously damaged by large herds. Grazing in a woodlot destroys young growth; open areas appear and become covered with grass, which means that the maintenance of the forest floor, which is so important to the health of the stand, is interfered with and there is less likelihood of a renewing of the stand by reseeding from old trees. These in turn become stag-headed and are easily preyed upon by fungus and disease.

Fire is not a serious factor menacing woodlands in the Catfish Watershed, but all landowners should have a knowledge of its effects. It is not necessary to burn a tree to kill it: merely raising the temperature of the growing layer inside the bark to 150 degrees Fahrenheit will do the job, and this is frequently what happens.

Due to the custom of grazing in the woodlots some stands have become open and require some planting. Of the areas examined 42 per cent are devoid of natural regeneration and 56 per cent require some planting to bring them back to fully stocked stands. Cutting in woodlots and clean-cutting of whole areas has been carried on persistently in the past, but since both the counties of the watershed now have diameter limits this practice has now ceased.

To sum up, 92 per cent of the woods are second growth with a mixture of large trees in many areas, and of these 18 per cent are young growth, the former ranging from 30 to 50 feet in height. The woodlots containing the largest trees are composed of old hardwoods, elm and soft maple in the swamp areas and sugar maple beech and basswood on dry sites.

CHAPTER 4

CONSERVATION MEASURES IN PROGRESS

When one speaks of plantable land, the first thought of most people is of light, sand land, usually of the "blow sand" type which is the easiest and most economically feasible land to reforest. Most of the reforestation in Ontario to date has been on this type of soil, small areas of which exist in the Catfish Watershed. In addition there are many places where the land is too poorly drained or too steep for agriculture, which should be reforested. Since there are few sand lands in the area, wind erosion is not a serious problem, although sheet erosion and some gullying occur on the steeper slopes.

For forestry purposes the Department of Lands and Forests has divided Southern Ontario into Forest Districts which are subdivided into zones. Each zone has its Zone Forester and assistants, whose duty it is to give advice and assistance to private individuals and municipalities on the management of their woodlands and the establishment of plantations. The office covering the zone in which Elgin lies is located in Chatham and the office for Oxford County is in Stratford.

The nearest forest tree nursery to the Catfish Watershed is that at St. Williams in Norfolk County, which was established in 1908 and has served as the largest production and distribution centre for trees ever since. Today, 43 years later, the Norfolk Provincial Forest Station of 3,800 acres presents a magnificent young forest of pines and other species. This station also maintains a small sawmill, in which thinnings from improvement cuttings are being manufactured into materials for local use. Thousands of visitors go to this beauty spot and a small park is provided for their accomodation. Many officials of municipal and other organizations from all parts of the Province have

visited this station and returned convinced that all the waste areas of the Province should be reforested and so made useful and beautiful.

1. <u>Private Planting</u>

Reforestation, combined with the protection of natural woodlots, is essential if farmers are to have sufficient woodland to supply the local community with fuel-wood, fence posts and poles, and to have a few saw-logs for sale which will provide a cash crop at times when the prices of other farm products are depressed. Reforestation of certain areas will not only mean that the land will be producing a crop where little or nothing of value is growing now, but it will also provide adequate protection for the soil and will retard run-off of water from melting snow and rain, thus making for a more even stream flow throughout the year.

The free distribution of trees for planting was first begun in Ontario in 1905, and the following year a statute was passed which permitted a township council to exempt a part of the woodland of a farm from taxation; it provided that exemption be extended to any part of a farm used for forestry purposes or being 'Woodlands'; provided that such exemption shall not be greater than one acre in ten acres of such farm and not more than twenty acres held under a single ownership.

> "'Woodlands' for the purpose of this paragraph shall mean lands having not less than four hundred trees per acre of all sizes, or three hundred trees, measuring over two inches in diameter or two hundred, measuring over five inches in diameter (all such measurements to be taken at four and one-half feet from the ground) of one or more of the following kinds: White or Norway Pine, White or Norway Spruce, Hemlock, tamarack, oak, ash elm, hickory, basswood, tulip (White wood); black cherry, walnut, butternut, chestnut, hard maple, soft maple, cedar, sycamore, beech, black locust, or catalpa, or any other variety which may be designated by Order-in-Council, and which said lands have been set apart by the owner with the object chiefly, but not necessarily solely, of fostering the growth of the trees thereon and which are not used for grazing livestock." - R.S.O. 1950, c.24, s. 5(18).

In 1927 the exemption of taxation on woodland

Land of this nature is in small areas privately owned; every inducement should be given the owners to reforest it.

This is part of the area which is under consideration as a source of water for the town of Aylmer. It should be purchased and reforested.

was made compulsory if applied for, and is interpreted as meaning planted as well as natural trees.

In 1938 The Assessment Act was amended to prevent the assessment being raised on land after it had been reforested and now reads as follows:

> "Land which has been planted for forestation or reforestation purposes shall not be assessed at a greater value by reason only of such planting."
> - The Assessment Act, R.S.O. 1950, c.24, s. 33(12).

Both these Acts were designed to facilitate the planting of trees on private land and should be taken advantage of by citizens anxious to improve woodland conditions on their own property and at the same time benefit the whole community of the river valley.

Within the Catfish Watershed there are 50 private plantations, most of which are small, namely one to twenty-six acres in area, with a total of 102 acres.

2. <u>County Forests</u>

The County of Hastings was the first in the Province to interest itself in reforestation and as long ago as 1911 appointed a reforestation committee which was instrumental in having The Counties Reforestation Act passed which has since been incorporated in The Trees Act. The committee also recommended[1] that "The Corporation of the County of Hastings purchase from the municipality of the Townships of Elzevir and Grimsthorpe certain lands containing 2,800 acres, more or less, for $200" as the nucleus of a county forest. However, no further action was taken and the act lay dormant till 1922 when the present policy of county forests was laid down. The work is done under the authority of The Trees Act (R.S.O. 1950, c. 399), which provides for the purchasing of land and the entering into agreements by the county for the

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1. Minutes of the Meeting of the Council of the County of Hastings, December 8, 1911.

management of such lands. No limit as to the size of the area is stated, so that some counties have plots of a few acres while others have forests of several thousand acres. If, however, a county wishes to enter into an agreement with the Minister of Lands and Forests for the planting and management of such county-owned land, it is preferred that the county purchase not less than 1,000 acres. The agreements which are in force at the present time run for a period of 30 years, during which time the Ontario Government agrees to establish the forest and pay the cost of such items as fencing, buildings, equipment, labour, maintenance, trees, etc. - in short, everything connected with the management of the forest.

At the end of the 30-year period the county has the privilege of exercising one of three options: First, to take the forest over from the Government and pay back the cost of establishment and maintenance without interest; second, to relinquish all claim to the forest, whereupon the Government will pay to the county the cost of the land, without interest; third, the forest may be carried on as a joint undertaking by the Province and the county, each sharing half of the cost and half the profits.

It will be seen from the above summary of the agreement that all a county stands to lose on such a project is the interest for 30 years on the purchase price of the land. Also, it should be pointed out that in drawing up such a liberal scheme it was done purposely to encourage the reforestation of land not suited to agriculture. Again, it was not the intention of the Government to have the counties stop at a minimum of 1,000 acres, as the overhead necessary on an area of this size could very easily be spread over an area of five or even ten times the size. As a matter of fact this is what happened in some counties where the councils have initiated a progressive reforestation policy.

This Act also provides that municipal councils

of townships shall have all the powers, privileges and authority conferred on councils of counties except that instead of issuing debentures to an amount not exceeding $25,000 they shall have power to levy, by special rate, a sum not exceeding $1,000 in any year, for the purpose of providing for the purchase of land for planting and protecting the timber thereon.

The agreements which have been drawn up between the Ganaraska, Thames and Humber Authorities and the Ontario Government to establish and manage the Authority forests is substantially the same as that made with the counties, except that the Government has agreed to pay half the cost of the land and the agreement for planting and management is to run for approximately fifty years. The Authorities pay taxes on the land and some townships prefer this to the county agreement where no taxes are paid.

Oxford County now has a forest comprising 515 acres in five separate tracts, none of which are in the Catfish Watershed. Elgin County has no county forest.

3. Municipal Forests

Municipal forests are areas owned and managed by municipalities other than counties. None have been established in the Catfish Watershed.

The town of Woodstock derives its water from wells near Cedar Creek south of the town. Forty acres in this vicinity are owned by the municipality and the planting of trees has been carried on periodically since about 1913. Most of the trees planted have grown well and the plantation is observed by thousands of people every year. It stands as a credit to the town and an inspiration to others; at the same time it is protecting the water supply and is a potential source of lumber. It could, however, be enlarged considerably.

Assistance with regard to the establishment of municipal forests and the supplying of free trees is still

the policy of the Department of Lands and Forests. Moreover, as provided by The Trees Act (R.S.O. 1950, c.399), it is possible for a township council to enter into an agreement with private landowners for the reforestation of their property. The agreement will prescribe the cutting conditions of all trees planted and such conditions will be subject to the approval of the Minister of Lands and Forests.

Provision is also made for exempting such lands from taxation and for making arrangements with the Dominion and Provincial Ministers of Labour regarding conditions of labour and payment of wages in connection with planting and conservation of such areas. - The Trees Act.

Before leaving the subject of municipally owned forests and forests which on a large scale would provide the local communities with at least a part of their livelihood, it would be as well to review what is being done along these lines in other places.

In Nova Scotia there is a community living on Hammonds Plains near Halifax, which depends entirely on wood taken from small woodlands for its livelihood. In this the largest woodlot is not over 400 acres in extent and because of the rocky nature of the soil the people are not able to augment their incomes by farming, though most families own a cow, a pig and some chickens. The wood from the woodlots is manufactured into barrels and boxes by more than twenty small mills which are largely family-owned and -operated. The people are thrifty and industrious; they have comfortable homes, are public-spirited and extremely forest-fire conscious. This is a community which has developed naturally and yet resembles communities based on a forest economy which have been planned and established in Europe for a considerable time.

One of the most recent is the forest of Ae in Dumfriesshire, Scotland. It was established by the British Forestry Commission in 1927 and covers an area of 10,683 acres of which 3,000 acres have been planted, 4,500 acres are

scheduled for planting in the near future, 250 acres of the best land have been set aside for cultivation, and the balance of 2,800 acres is unplantable because of its altitude but is used for sheep pasture in summer.

The forest is in charge of a forester who resides on the spot and under him there are foremen and gangs of workers. In the first year 16 men were employed, just before the war 27 full-time employees were engaged, and by 1960 about 90 men (or one man for each 80 acres) will be needed the year round for essential forest work. This does not take into account temporary employees who will be required for sawmilling, transport and other jobs. It is planned to create a forest village for the workers embodying a church, a school, playgrounds and sportsfields. The combination of the forest and the village dependent on it is something new in Scotland and represents an important stage in the resettling of men and women in the country. The village is to be the forerunner of other similar villages and in many parts existing villages will be revitalized by the stimulus of forest wealth.

4. Demonstration Plantations

In 1922 the Provincial Government began the policy of assisting municipalities in the establishment of small forest plantations for the purpose of demonstrating the use of trees on marginal and submarginal land. To meet the requirements for such a plot the Government required that the area be on a well-travelled road so that as many people as possible could see it; that the municipality either purchase land or use land which was in its possession, fence it, and agree to give the area reasonable protection after planting. In return the Government agreed to supply the trees and pay the cost of planting and of supervising the work when the planting was in progress. In 1932, when Government funds were curtailed, the policy governing these demonstration plots was changed, and from that time to the present the Government

has not paid the cost of planting, although the other conditions governing the establishing of these plots have remained the same.

There are no demonstration plantations on the Catfish Watershed. The value of such plots, if well cared for, in showing landowners what can be accomplished in a very few years by planting trees is so great that every township should endeavour to establish at least one plot.

5. Demonstration Woodlots

Demonstration woodlots are privately owned areas of woodland on which the owners have agreed to follow prescribed methods of woodlot management, outlined by the Department of Lands and Forests, under the Zone Forester and to permit access to the area by interested persons. Such demonstration woodlots and the influence they exert for the proper management of similar areas contribute to the total conservation effort in any watershed.

No demonstration woodlots have been established on the Catfish Watershed.

6. School Forests

In order to encourage the establishment of school forests planted and cared for by school children, the Ontario Horticultural Association in 1945 organized an annual competition. Prizes are offered for the school having the best plantation and knowledge of forestry in each forest district in Southern Ontario and for provincial winners from the winners in the district. Prizes for these competitions are generously provided by the Ontario Conservation Association and private donors.

Trees have also been sent out to schools in the watershed and have been distributed to children for planting on the home farm, and many of these have been used to form shelterbelts and windbreaks, but no school forests have been

established.

7. Boys and Girls Forestry Clubs

These clubs are organized by the Ontario Department of Agriculture assisted by the Department of Lands and Forests and must be sponsored by an organization interested in the improvement of woodland and reforestation.

Members must be between 12 and 21 years of age and each member undertakes a project such as marking a half-acre plot of woodland for thinning or reforesting a quarter-acre of land. Projects are judged annually on Achievement Day and prizes awarded; for this purpose the Department of Agriculture furnishes $3 per member and the sponsoring organization $1.50. Winners may enter the Provincial Inter-Forestry Club Competition.

To date none of these clubs have been founded in the Catfish Watershed.

NATURAL WATER STORAGE AREAS
AND
REFORESTATION LAND

1. BROWNSVILLE
2. GLENCOLIN
3. SUMMERS
4. SPRINGWATER
5. JAFFA
6. SPARTA
7. PORT BRUCE

SCALE : MILES

1 0 1 2 3

CHAPTER 5

FOREST CONSERVATION MEASURES REQUIRED

1. Natural Water-Storage Areas and Reforestation Land

One of the most important conservation measures required on the Catfish Watershed is the establishment of forest areas, to be called the Catfish Forest, under the Conservation Authority, which will serve to protect the natural water-storage areas of the valley. Seven such areas have been defined, as shown in the accompanying table, with the acreages of woodland, scrub and cleared land in each. The one-page map shows the location of these areas and the main tributary streams to which they supply water. The names given to these areas are taken from nearby places. The large folding map in the back gives more detail, showing the present tree cover, willow scrub, hawthorn and open land within the areas. The total acreage recommended for acquisition includes natural water-storage areas and reforestation land to the extent of 3,100 acres of which 1,018 have some form of tree cover, 386 are willow scrub or hawthorn and 1,696 are open land.

In selecting the areas which it is felt should be set aside as permanent natural water-storage areas, adjacent swampland has been included irrespective of its present vegetative cover, that is, all soft maple and white elm woods, willow and dogwood thickets, bog land and marsh areas have been included. In addition, adjacent woodland, particularly on slopes and covering springs, has been included as well as adjacent gravel pits. The minimum of land in the better land classes has been included, but in some cases it was impossible to omit them entirely when they occupied positions immediately above springs or on a small part of a lot which was mostly composed of a poorer type of soil.

(1) Brownsville

The Brownsville area lies near the headwaters of the main stream. It has been largely cut over and used

This hardwood swamp is typical of the natural water-storage areas of Southern Ontario. Where they are extensive their preservation should be assured by acquisition of the land by the Authority.

Land such as this has been cleared for pasture but in most cases it is inadequately drained and its tree cover should be restored.

as low-grade pasture which has been invaded by hawthorn. The total area recommended for acquisition here is 500 acres, 70 acres of which are still wooded, including 43 acres of white elm - silver maple bush; hawthorn covers 104 acres and 326 acres are open land.

(2) Glencolin

This area is one which the Town of Aylmer has been considering as a possible source of water for the town. The report on ground-water studies states that this area is a suitable one provided that the aquifer from which the water is drawn be recharged by surface water. It also suggests that the lowering of the level of available water is partly due to deforestation. It comprises 500 acres, 80 acres of which are wooded, 83 acres covered with scrub (23 acres of which is wet scrub, mostly willow, and 60 acres dry scrub, largely hawthorn) and the remainder is open land.

It is therefore recommended that the Authority acquire this property, reforest the open land and preserve the existing woodland.

(3) Summers

Summers is an area of about 600 acres, much of which is very poorly drained. There are 108 acres of woodland including 24 acres of plantations, mostly of Scotch and red pine, with some spruce and elm ranging in age from four to eleven years; 158 acres are scrub land of which 120 are covered with willow scrub and dogwood and 38 with hawthorn; the remainder is open land.

(4) Springwater

Springwater, as its name implies, is the most important source of water for the Catfish Creek. The bush is one of the few outstanding examples of almost unspoiled natural woodland in Southern Ontario. It contains many thousands of board feet of timber including white pine, white oak, sugar maple and beech in great trees which have been growing since before the days of settlement. It contains

800 acres in all, of which 515 are woodland, including 12 acres of plantations; 30 acres are scrub, most of which is hawthorn; and 255 acres are open land. It is recommended that the Authority make every effort to acquire this property as soon as possible. This would entail engaging a qualified person to make an estimate of the value of the timber, which must be considerable, but as a great deal of it is mature and could be profitably managed under the direction of a forester there is no doubt that the Authority could recover the money invested in it in a very few years. Otherwise it will certainly be cut in the near future, probably by some ruthless logging operator, and its aesthetic and conservation values lost to the watershed.

(5) Jaffa

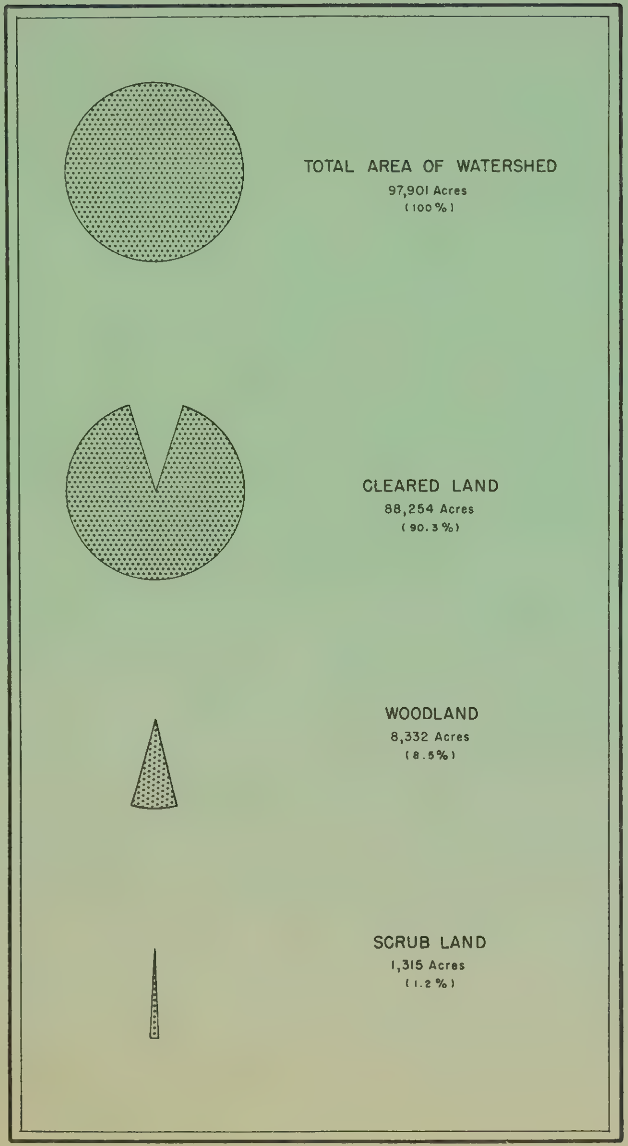
Jaffa is a small tract of 100 acres on the west side of the valley of Catfish Creek; part of it is the flood plain of the stream and part the rough land formed by the steep slopes of the valley. It contains a large gravel pit which is still being worked. Much of this could be reforested at the present time and the remainder when the pit has been worked out. There are 9 acres of woodland and the remainder is open land, including the gravel workings and pasture.

(6) Sparta

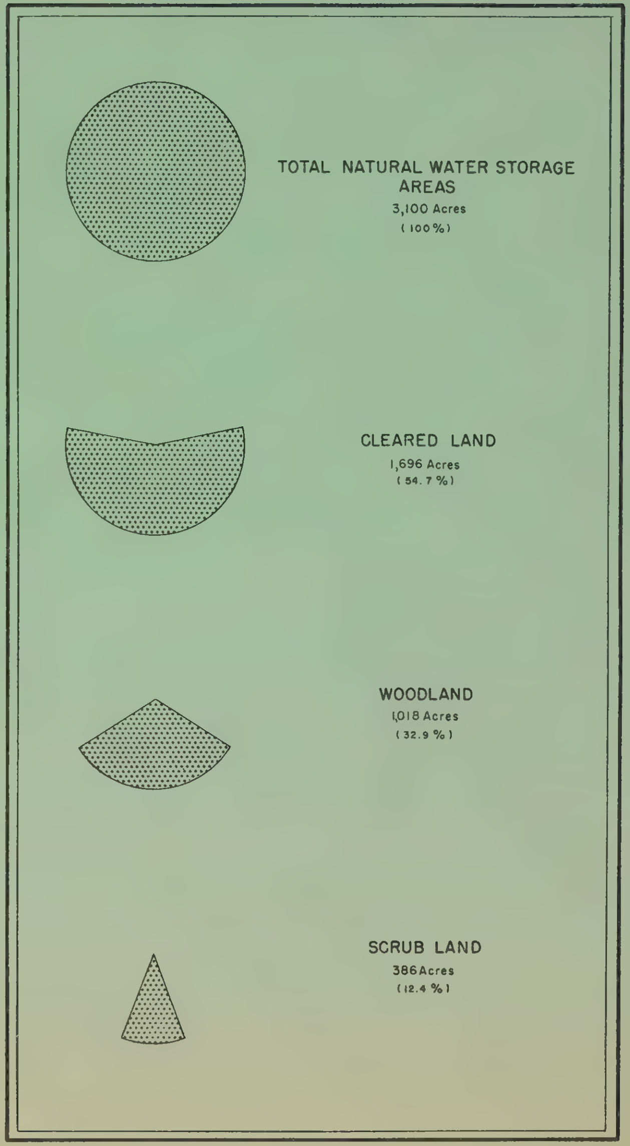
The Sparta area is one of very rough pasture land created by two small tributaries of the Catfish which, like the main stream, have cut deep valleys into the land. Of the 200 acres, 83 are wooded, 11 acres are covered with hawthorn scrub and much of the remaining 106 acres of open land has hawthorns scattered over it. Hawthorn is in fact gradually taking over the whole area and as it is impossible to maintain pasture on such steep slopes it should be reforested.

(7) Port Bruce

This tract is similar to the previous one, made up of very hummocky topography where it is impossible



LAND CLASSIFICATION – TOTAL WATERSHED



LAND CLASSIFICATION – NATURAL WATER STORAGE AREAS

to maintain permanent pasture. It comprises 400 acres, 153 acres of which are wooded and the remainder low-grade pasture. This area too should be acquired by the Authority as part of its forest and the open land reforested.

NATURAL WATER-STORAGE AREAS
AND REFORESTATION LAND (IN ACRES)

Area	Cleared	Woodland	Scrub	Total
1. Brownsville	326	70	104	500
2. Glencolin	337	80	83	500
3. Summers	334	108	158	600
4. Springwater	255	515	30	800
5. Jaffa	91	9	0	100
6. Sparta	106	83	11	200
7. Port Bruce	247	153	0	400
Total	1,696	1,018	386	3,100

2. Scrub Land

The total area of scrub land on the Catfish Watershed is 1,317 acres of which 908 acres are dry scrub and 407 are wet scrub. In other words one acre in every 74 is scrub land and absolutely non-productive. This is in one of the most highly productive agricultural areas of Southern Ontario.

Scrub land has been placed in two categories: dry-sited scrub which includes such species as hawthorn, apple, sumach and witch hazel, and wet-sited scrub - willow, dogwood and alder. Dry-sited scrub land is usually land which has been overgrazed and neglected for many years. The soil may be unsuited to agriculture because of poor quality, excessive steepness or inaccessibility. On the other hand, it may be fairly good farmland which the owner has not been able or willing to maintain in good pasture so that shrubs whose seeds are spread by birds and which are unpalatable to cattle have taken over the area.

Wet-sited scrub land is land with imperfect drainage, often bordering swamps. The bush has been cleared from it but the subsequent pasture has been so poor that shrubs such as willow and dogwood, which require a damp site, have invaded the area.

Frequently scrub areas of these two types are suitable only for trees. They should be reforested and the acquisition of some of them by the Authority has been recommended. The wet-site areas present a problem in planting, and research should be undertaken to determine the best method of handling them. There appears to be a natural succession from neglected pasture land through willow scrub, trembling aspen, white elm and black ash to the climax types of silver maple - white elm or black ash - white elm - red maple, and every effort should be made to determine the best method of speeding up this succession.

In addition to the larger areas there are innumerable smaller areas, often in long strips along the borders of stream valleys, which will always be in private hands. The aggregate effect of this on stream flow is very considerable and the areas of this type are shown on the soil maps. These should be planted with trees to form part of the farm woodlots where they occur. Many of them should be placed under a reforestation and controlled woodlot scheme by agreement with the Authority, especially where they cover the sources of streams or steep slopes where erosion is or may become a problem. Under this scheme the owner would get considerable help from the Authority in the establishment and maintenance of the woods, but would not be permitted to cut them indiscriminately. (See Controlled Woodlot Management.)

3. Controlled Woodlot Management

Before the necessary conservation measures on that part of the watershed exclusive of the proposed

Catfish Forest can be properly co-ordinated, some system of controlled cutting of privately owned woodlots must be established. The reason for this is that the average owner does not take a broad view of the value of forest cover and is not interested to any great extent in what may happen to land or stream flow off his property. The result is that throughout the watershed there is a systematic cutting of woodlots for the purposes of lumber and firewood. The type of cutting has been in progress for many years, and the portable sawmill has done a great deql of damage in removing, particularly, young, thrifty trees. The system of selling acre or half-acre blocks of timber for fuelwood is also another vicious practice, for the reason that when a purchaser buys such a block, in nearly every case he clean-cuts every tree which can be used, down to the minimum diameter limit. Some system of regulating cutting would correct this situation and certainly the areas which are connected in any way with the headwaters of streams, or the feeding of springs, should be controlled to the extent that they cannot be clean-cut.

Where conditions warrant, cutting would be continued, but should be controlled by agreement with the Authority and only such trees as are marked by a competent person should be cut. Provision should be made for restocking where necessary, the intention being to interfere as little as possible with the economy of farm property where the supply of wood is concerned. County by-laws restricting cutting passed under The Trees Act do not prevent an owner from clear-cutting any area if the wood is for his own use.

For many years now conservationists have advocated controlled cutting of woodlots. In some sections, particularly in tobacco-growing counties, the destruction of woodlots for the curing of tobacco has become alarming. It is admitted that the question requires delicate handling, but where the good of the whole community is envisaged some middle road of agreement could be arrived at. Furthermore,

the distribution of free trees by the government for conservation purposes is sometimes criticized, and rightly so, where on one farm the owner plants an area with seedlings and in the same year his neighbour clean-cuts a woodlot which perhaps protects the headwaters of a stream. In fact, so distorted is the relative value of plantations versus established woodlots in the minds of some people that there are examples on record where municipalities have purchased land for reforestation and have allowed the owner to cut the timber before giving title.

It is admitted, of course, that there are extenuating circumstances when a farmer may consider it necessary to raise money by selling timber. This in itself is not so serious if the cutting is done in such a way that the benefits of the forest are retained. Young forests, as well as old, protect the soil and have water-regulating value.

The basis on which a regulation of this kind should be carried out is a consideration of the woodlot concerned. To make a blanket ruling that all woodlots on the Catfish should not be cut, or should come under one type of control measure, would not work to the best advantage of the community and certainly would not be in the interests of good forestry.

Some woodlots have reached the stage at which they are worn out and if the land is good should be cleared off and cropped. Others may be composed of a high percentage of worthless species and have no relation to water regulation in the countryside, and likewise could be disposed of to advantage. But where the woodland has a direct bearing on water regulation, erosion, retarding of the wind and similar benefits, the desire of the individual should be sacrificed for the good of the community. The whole question, therefore, resolves itself into an examination of each woodlot by a competent person and the prescribing of a program of management to suit each case.

4. Fencing Woodlots from Cattle

One of the most progressive steps taken in Southern Ontario in recent years was taken by the County of Halton in 1948 when the County Council passed a by-law to aid farmers in fencing their woodlots from livestock.

The by-law states that the County of Halton will grant a sum equal to the prevailing cost price of 8-strand fence wire with a single barb (not the cost of posts or labour) to a woodlot owner who will erect such a fence on one or more sides of his woodlot in order to completely enclose the woodlot, thus fostering forest growth by keeping livestock out. The woodlot must be of a size not less than two acres and livestock must be excluded for a minimum period of ten years.

Such action by the County Council is of infinitely more value than the planting of many millions of trees artificially. Every county should pass such a by-law and it is recommended that the Conservation Authority adopt a similar scheme.

5. Diameter Limits

The basic method of control usually advocated is cutting to a diameter limit; that is, that all trees below a certain diameter - for example, ten inches - should not be cut. Such a regulation may or may not be good forestry. In most cases it would not be, because there would be much worthless material below this diameter limit, such as poplar, thorn, willow and other species, which should be taken out. At the same time there would be certain large trees above the diameter limit which should be left for the benefit of the forest, as well as trees suitable for reseeding the area. The diameter limit should not be a fixed rule but simply a guiding principle, a sort of yardstick on which the landowner can base his calculations. In an area the size of the Catfish Watershed a program of individual woodlot

COUNTY BY-LAWS RESTRICTING THE CUTTING OF TREES UNDER THE TREES ACT

County	Date Passed	Diameter Limit (inches)	
		Cedar & Certain Species	Most Species
BRANT	Nov. 2/48	5	14 Stump 18"
BRUCE [1,2]	Jan. 23/48	6	12 Stump 18"
DUFFERIN [3]	Nov. 28/47	5	12 Stump 18"
DURHAM [4]	June 12/47	5	10 D.B.H.
ELGIN [5]	Jan. 24/47	5	12 D.B.H.
GREY [2] (except Keppel Tp.)	June 27/47	6	12 Stump 18"
HALDIMAND [2,6]	May 13/49	6	14 Stump 18"
HALTON	Apr. 15/47	7	14 Stump 18"
HURON	Nov. 21/46	5	12 D.B.H.
LAMBTON	June 12/48	7	12 Stump 18"
LEEDS/GRENVILLE [7]	June 21/47	0	0
MIDDLESEX	Mar. 12/47	6	14 Stump 18"
NORFOLK	Jan. 23/47	6	14 Stump 18"
OXFORD	Sept.13/46	5	12 D.B.H.
PERTH	Jan. 25/47	5	16 D.B.H.
WATERLOO	Oct. 23/46	5	14 D.B.H.
WELLINGTON	June 15/46	5	12 D.B.H.
WENTWORTH	May 12/49	6	14 Stump 18"
YORK [8]	Nov. 18/49	0	14 D.B.H.

D.B.H. is diameter breast high or 4½ feet above ground.

1. Limits apply only in the south half of Bruce County.
2. Bruce, Grey and Haldimand also have an 8-inch limit for poplar and birch.
3. Dufferin has a 10-inch limit on basswood.
4. Durham also has a 5-inch limit for birch, black locust, black ash, soft maple, tamarack and willow.
5. Elgin has a 5-inch limit for black locust.
6. Haldimand also has the following: 8-inch limit on cherry, 10-inch limit on birch, 12-inch on basswood, chestnut, coffee, cucumber, gum, hackberry, sycamore, hemlock and tulip.
7. Leeds and Grenville have imposed no limit and the by-law is almost worthless from a forestry point of view.
8. York has no limit on poplar, Manitoba maple, black locust, tamarack, white birch and willow.

examination should not be too heavy a burden on the Conservation Authority.

Nineteen counties, including Elgin and Oxford, have passed by-laws under The Trees Act (R.S.O. 1950, c. 399) which empowers a county council to pass by-laws restricting and regulating the cutting of trees. In each case the by-law has fixed minimum diameter limits below which trees may not be cut except in special circumstances. The object of this is to prevent the cutting of trees at the time when they are putting on their greatest diameter growth. These limits are usually 5 or 6 inches for white cedar, red cedar and black locust and range from 10 inches to 16 inches in the various counties for all other species. The limits which have been set are actually far too low for the final crop trees as most trees are making their maximum diameter growth after they reach 18 inches in diameter, but it is an elementary step in the right direction. Every county should have restrictions of this type and it is recommended that similar powers be extended to Conservation Authorities as a means of protecting existing woodland on their watersheds.

6. Forest Fire Protection in Southern Ontario

The task of protecting woodlands from fire in Southern Ontario presents a very different problem, or rather series of problems, from those of Northern Ontario, and consequently must be handled in a somewhat different manner. Though fire is not a serious question on the Catfish Watershed, it is a question to which some attention should be given.

Northern Ontario is predominantly forest land, the population is sparse, parties travelling through the forested areas are fairly readily accounted for by means of a permit system during the fire season, and watch is maintained for fire by means of look-out towers and air patrol.

In Southern Ontario south of the Laurentian Shield the land is normally potential agricultural land with the woodland surviving in isolated patches as farm woodlots or in larger more or less continuous blocks of swamp or sand up to ten thousand acres in extent. The population is, relatively speaking, fairly dense, no part of any woodland is more than two miles from the nearest human habitation and most roads are travelled by a comparatively large number of people.

The first step in fire control is fire prevention, and the best assurance of prevention is an enlightened public opinion which will make every member of the rural community conscious of the seriousness of fire damage and of his duty as a citizen to do all he can to prevent it. The farmer can prevent most fires in farm woodlots if he exercises the same care that he does around his home and buildings.

CHAPTER 6

FOREST INSECTS AND DISEASES

1. Forest Insects

In any project, such as that proposed for the Catfish Watershed, careful consideration should be given to the prevention of insect outbreaks and adequate arrangements made for the immediate application of control measures when these become necessary. While it is not possible to predict accurately the course insects may take under the ever-changing conditions of a newly forested area, there are a number of fundamental principles which, if applied, will greatly lessen their destructiveness.

It is important to avoid the planting of large areas of one kind of tree, otherwise conditions will be ideal for an outbreak of abnormal numbers of some insects which prefer the food afforded by that particular host. It is preferable to plant in blocks, the blocks distributed so that trees of one species are separated by blocks of different tree species. This tends to keep outbreaks localized until natural agencies bring them under control and facilitates direct control measures if such become necessary.

It is important to plant only the species of trees suitable to the site and existing growing conditions. Healthy, vigorous trees are certainly more resistant to insect attack than weak, struggling ones.

Over-mature and dead trees should be removed from the existing stands as these harbour bark-beetles and wood-boring insects which may become excessively abundant and attack healthy adjacent trees.

Care should be exercised to prevent ground fires. Even light ground fires are frequently followed by severe outbreaks of bark-beetles and wood-boring insects.

Woodcutting operations, sawmill sites and wood storage yards should be carefully supervised or they may become reservoirs of infestation.

It is essential that surveys for insect conditions be made each year so that any abnormal increase in insect populations may be noted and control operations initiated before they develop to outbreak proportions. Serious and widespread outbreaks are frequently prevented by prompt and well-timed spraying operations over a comparatively small area. It is therefore necessary that spraying equipment be available and that laneways be maintained within the plantations for spraying purposes. Outbreaks of an extensive nature can generally be brought under effective control by strip spraying. In this method, alternate strips of trees in large plantations are sprayed, thus reducing the initial infestation and at the same time causing the native parasites to concentrate and build up in the unsprayed portions. This reduces spraying operations and the number of lanes required for the passage of spraying equipment.

Owing to the danger of injury by the white pine weevil, white pine should not be planted in pure stands unless the stands are very densely stocked in a good site. It is better to grow white pine in mixture with some immune species such as the better hardwoods. The protecting species should be taller than the white pine, at least in the early years.

In conclusion, it should be recognized that protection against leaf-feeding insects is very desirable since defoliation of a tree weakens it and thus makes it more susceptible to attack by bark-beetles and wood-boring insects as well as by organisms which do not usually attack healthy trees but which will hasten the death of weakened trees. Leaf-feeding insects alone may kill a thrifty, broad-leaved deciduous tree by completely defoliating it for three years in succession. Conifers, however, are usually killed as a result of one complete defoliation.

2. Tree Diseases

Productive woodlands require protection against fire, trespass, grazing animals and rodents, insects and disease. Protection is a part of forest management, and under a policy of sustained yield will be maintained in continuity. Good forest management is reflected in the health of woods and, conversely, damage on account of disease is often a sign of mismanagement or neglect. In general, an objective of maximum yield, with attendant intensive silviculture, is compatible with, and often facilitates, protection and disease control.

For the purpose of discussing their pathology and protection, the hardwoods may be considered separately from pine in natural stands or plantations. The chief diseases of the hardwoods are the various trunk, butt and root rots, and chronic stem cankers, which are all endemic and may cause serious damage under aggravating conditions. Woodlots on the Catfish Watershed present very diverse conditions with respect to the incidence of these diseases, a circumstance which is usually related to their past history. Thus many containing old timber are in need of heavy preliminary salvage and sanitation cuttings as a result of mismanagement or neglect. Such cuttings should precede or be combined with cleanings and improvement cuttings, designed to improve the composition and structure of the stands. Having established a sanitary condition, normal care should maintain it and obviate loss on account of decay.

The wood rots are commonly thought of as diseases of mature and over-mature timber, but experience has shown that infection may occur at a very early age. In hardwood sprouts the stem may be infected from the parent stump. In older trees infection is chiefly through wounds, either of the root or trunk, which may be caused by fire, trampling by animals, insects, meteorological agencies, or by carelessness or accident in felling and other woods operations.

Hardwoods are commonly cut selectively and not infrequently in clear fellings. Few foresters will approve the latter system, which is in fact often intended as a liquidation of the property. A system based on yearly selection, or frequent periodic return to conveniently planned subdivisions, has obvious advantages for small woods, and is well adapted to the control of decay.

For many reasons "cleanings" in the reproduction are desirable, especially where the woods have been heavily cut. While favouring the valuable species, those sprouts which, on account of decay hazard, are of undesirable origin should be eliminated. Such will comprise sprouts from the larger stumps and those from above-ground position.

In harvest cuttings, which should recur at frequent intervals, the permissible volume allotted should include trees in which incipient decay is discovered and so far as possible those which have become a poor risk through injury or other circumstances.

White pine is found in young plantations and in natural stands, almost pure or mixed with hardwoods. From the latter stands it tends to disappear on account of hardwood competition, except on sites which are particularly favourable for its reproduction. The white pine blister rust, which with the well known shoot weevil is a principal enemy of the species, is a factor contributing towards the elimination of seedlings and young trees.

White pine should be encouraged on those sites which are naturally suited to its reproduction so that fairly compact growth may be secured, thereby facilitating the protection problem. It is an important and valuable species in Southern Ontario, and its cultivation should be promoted by the institution of effective blister rust control facilities.

CHAPTER 7

LAND ACQUISITION

The problem of land acquisition in any part of agricultural Ontario, where practically all the land is privately owned, is one which requires careful approach. The ownership and use of land, especially for agricultural purposes, is considered by most citizens as one of their few remaining inalienable rights. However, where the good of the whole community is under consideration, such personal rights should be, and have been, overruled under the principle of eminent domain. Examples of such cases are the building of highways, the construction of power lines, and the acquiring of land for military purposes in the event of a national emergency.

In Southern Ontario compulsion has not been exercised to any great extent by the Government in planning proper land use schemes. But who would gainsay the fact that the acquiring of poor land on the Catfish Watershed for conservation purposes constitutes a national emergency, and therefore requires a more permanent authority than the individual to bring it back to its proper use.

However, in dealing with land acquisition it should not be the desire of any authority to approach the problem in a dictatorial manner. It will require careful handling, and as a preliminary step in such work the people of the area should be acquainted with the purpose of the scheme, its ultimate benefits to the community, and by explanation and demonstration be gradually brought to the point where they will be glad to co-operate.

The only part of the Catfish where large-scale transfers of property from private ownership to a forest authority would have to be made is in those areas which are recommended for acquisition because they are natural water-storage areas and reforestation land.

1. Methods of Acquiring Land

There are several ways in which land can be acquired and controlled for conservation purposes, and it is proposed to enumerate and discuss these briefly in this section.

(a) Transfer by Private Sale

The most satisfactory method of acquiring land is by private sale between the Conservation Authority concerned and the landowner. This method has been followed by the counties of Ontario in purchasing land for reforestation work in building up the system of county forests, which totals in round figures 65,000 acres. This method has its drawbacks, however, as individuals who have not the community's welfare at heart, or for one reason or another have an exaggerated idea of the value of their property, may block the completion of a unified area by refusing to sell. This was overcome in the State of New York, which has purchased over 450,000 acres of land for reforestation, by refusing to buy individual parcels of land unless there was a sufficient number in a group to make a contiguous block of 500 acres.

(b) Maximum Price per Acre

Another method which has been used has been to fix a maximum price per acre for this class of land, beyond which the forest authority is prohibited to go, allowance being made for the presence of good fencing and buildings on the properties, which in some cases have been removed by the vendors and allowed as part payment for the land.

(c) Agreements

Where owners of perperty prefer to retain their woodlots, or where parts of farms fall within the forest area prescribed, and providing the retaining of ownership does not jeopardize the complete conservation scheme, agreements could be made for the control and management of such areas.

This method has been adopted by the Dominion Forest Service in Nova Scotia, where it has been desirable to control wooded areas for experimental and conservation schemes, and in this particular case the agreements cover a period of twenty years.

In Ontario there is one example, at least, where a municipality leased a part of a farm for reforestation work for fifty years, and one United Counties council has adopted the plan of taking easements on land for the same purpose.

(d) Control by Existing Legislation

Under the authority of the Private Forest Reserves Act (R.S.O. 1950, Chapter 288), the Minister of Lands and Forests, on recommendation to the Lieutenant-Governor in Council, may, with the consent of the owner of any land covered with forest or suitable for reforestation, declare such an area to be a private forest reserve. When such an arrangement is made the Minister or his representative may reforest such areas, supervise the improving and cutting, and prohibit the removal of trees by the owner without his consent, and also prohibit the grazing of the area by cattle.

(e) Life Lease

Many of the farms on the proposed forest, as already mentioned, are of low agricultural worth and are supporting families at the present time. The problem in such cases is not so much the purchase of the property as what will become of the family after the farm is acquired. In almost every case it would be impossible for the vendor to purchase another farm with the money he receives, except one which is of approximately the same value outside the forest. In some cases such farms are occupied by older people whose families have grown up and left the community. The removal of these from their properties might work undue hardship on them, and in fact in some cases they might become a burden on the municipality. With some of these the plan of giving the

vendor a life lease would be sufficient. In most cases such old people make little attempt at farming the whole property, but require only sufficient pasture for a cow or two, enough land for a garden, the house and buildings, and a supply of fuelwood. The plan of giving a life lease has been adopted in the case of two properties,[1] at least, on the county forests in Ontario, and has proved satisfactory to both contracting parties.

(f) Tax Delinquent Land

Under the Statutes of the Province of Ontario,[2] land which becomes tax delinquent is sold by the County Treasurer. In the case of a farm this is not done in practice until the land has been in default for three, or in some cases, four, years. Even then the owner has the privilege of redeeming his property within a year. Where such lands are marginal or submarginal, they are sometimes bought for only a part of the area which is of special value, such as woodland, old buildings, or a good field or two. In some instances the poor land remains idle and frequently appears again at the tax sale. The fact that such land becomes tax delinquent is an indication in many cases that its ultimate use is forestry. Under the present Statutes the municipalities are not permitted, at the first sale at least, to acquire or reserve such land for conservation purposes. Consequently this report recommends that the Authority expropriate all tax delinquent land subject to the regulations of the Municipal Act.

(g) Expropriation

As a last resort in land purchases, or where the owners of abandoned land cannot be located, such areas can be acquired by expropriation. The Conservation Authorities Act, R.S.O. 1950, Chapter 62, Section 15 states:

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1. Northumberland Forest and Angus Forest.
2. The Assessment Act, R.S.O. 1950, c. 24, s. 143.

> "For the purpose of carrying out a scheme an authority shall have the power to purchase or acquire and without the consent of the owner enter upon, take and expropriate any land which it may require and sell or otherwise deal with such land or other property."

Also under The Forestry Act (R.S.O. 1950, Chapter 147, Section 13) provision is made for the removal of settlers from lands unsuitable for farming. To quote:

> "Whenever in the opinion of the Minister, it is found that settlement has taken place on lands not suitable for agricultural purposes, and which said lands are required for forestry purposes, the Minister shall have the power to make arrangements for the removal of such settlers upon such terms as may be agreed upon."

As a matter of general interest, it should be stated that this Act also provides for the power to close the roads on lands taken over for forestry purposes, the setting apart of lands for settlement, and the removing of settlers from lands unsuitable for farming. It should also include, however, provision for acquiring permanent or community pastures, and pondage areas where these are required, as an integral part of a large conservation project.

2. <u>Cost of Land in the Proposed Authority Forest</u>

It would be impossible to give an accurate figure for the total purchase price of all land in the proposed forest without consulting the owners of the individual parcels. However, as an indication for arriving at the approximate cost the amounts paid by the several Conservation Authorities of the Province in purchasing land for their forests will serve as a guide.

TABLE SHOWING COSTS OF LAND PURCHASED FOR FORESTS

Name of Authority Forest	Acres	Cost $	Cost per Acre $
Ausable	634	12,700.00	20.03
Ganaraska	3,253	22,078.00	6.78
Humber	411	11,795.00	28.70
Thames	1,980	10,870.17	5.49
Total	6,278	57,443.17	9.15

It should be pointed out that land acquired in the future by the Ganaraska Authority is likely to cost more than the average price per acre of \$6.78, because most of the poorest denuded land has now been taken up and the remainder has more woodland and potential woodland which will naturally raise the purchase price. The very low cost of land in the Thames Watershed is explained by the fact that it is mostly burned-over swamp land with a peat soil which is of no economic value at the present time. Actually the average price of \$5.49 per acre includes a ditch tax which exists as a lien against part of the property, so that the price of the land itself was closer to \$1.00 per acre.

On the Thames Watershed, too, most of the poorest land has now been acquired and the cost of the remainder will certainly be higher. The development of a comprehensive conservation program is a long-term project and it may be fifty years before the Authority has all the land required. The present policy of acquiring and reforesting some land each year is a sound one, and where the cost of certain areas is too high the Authority can afford to wait, because the land is deteriorating in productiveness through cutting, fire, grazing and neglect and eventually the price must fall too.

CHAPTER 8

SNOW FENCES

In the climate of Southern Ontario snow drifting may cause much inconvenience and sometimes hardship. Control can be readily effected by means of windbreaks and is dependent on proper placing with reference to lanes of travel and topographic features.

Where space is limited or land valuable lath or board fences are frequently used, but the cost of erection removal or maintenance of these can be materially reduced by using trees as permanent windbreaks or shelterbelts. One or two rows of trees are usually referred to as a windbreak and more than two rows as a shelterbelt. The latter is preferable if space permits as it gives better and more permanent protection.

The prevailing winds in Southern Ontario are generally from the west so protection is usually required on the west side of north-south roads, on the north-west side of northwest-southeast roads and on the north side of east-west roads.

The object of a snow fence is to mechanically reduce wind velocity near the ground in such a manner as to cause a drift to form where it will be least harmful. The reduction in velocity creates two pools of relatively calm air, a small one on the windward side and a much larger one on the leeward side, and it is here that drifts form, leaving the area further to the leeward free of drifts and comparatively free of snow. The deepest part of the calm pool is close to the windbreak; if the windbreak is open at the bottom - that is, composed of trees with few or no branches near the ground - the deepest part will move further to leeward. As winds become stronger both the depth expressed in terms of velocity reduction and the width of the pool on the leeward side will increase and the centre will tend to

move further away from the windbreak.

A single row of trees, unless it is a dense coniferous type, is seldom dense enough to completely stop winter wind and may create drifts, just as poor placement of windbreaks may accentuate drifting conditions.

A wide belt of trees which will accumulate a large drift of snow on its windward side may be planted right to the edge of the road, the windward edge extending back a distance equal to three or four times the height of the trees and generally at least 100 feet.

In some places the snow trap type of windbreak is effectively used. It is composed of one or more rows of trees close to the road with a wide opening to windward and then a single row of trees. The single row arrests the first force of the wind and the snow is deposited in the opening. This has the advantage of requiring fewer trees than the shelterbelt and leaving the ground between open for cultivation in summer.

Any prejudice which may exist against windbreaks for protection against drifting snow on roads arises from poor or poorly placed windbreaks. If a windbreak has openings in it or if it ends abruptly streamer drifts will form. Windbreaks should be kept dense and tapered down at the ends by using progressively smaller species of trees and shrubs to prevent the formation of streamer drifts.

Trees are being used successfully as snow fences in Ontario by the Department of Highways, by railways and by a number of counties.

The practice of the Department is to acquire the land by purchase to a width of 100 feet from the centre line of the pavement and plant a three-row windbreak 80 feet from the centre line. The land is ploughed and cultivated and bushy stock about 2 feet high is used. Weeds are kept mowed between the rows and on the open strip between the

windbreak and the pavement, which entails a lot of work on the part of the maintenance crews in summer. The windbreaks are kept down to a height of 7 feet, partly because many farmers object to their view of the highway being obstructed and also because they are proud of their herds and fields which they want to be visible to passers-by. Also cutting the tops off the trees reduces the temptation, which some persons find irresistible, to cut them for Christmas trees.

County practice varies; sometimes the land is purchased, sometimes it is leased and sometimes it is planted by agreement. In all cases the County erects a fence behind the trees. In return for the use of the land one county plants a three-row windbreak around the farm buildings. Waterloo County has planted an excellent shelterbelt over four miles long on the west side of the county road running north through Linwood. Here the County has acquired a twelve-rod strip (198 feet) and planted the six-rod strip farther from the road, leaving the six-rod strip next to the road to catch the drift while the trees are small. When the trees get bigger it is planned to complete the shelterbelt by planting the six-rod strip next to the road. The trees used are transplant stock about one foot high obtained from the Department of Lands and Forests and planted in furrows. Weeds are kept mowed until the trees are large enough to shade them out.

The species of trees used are Scotch, jack, red and white pine, white and Norway spruce and white and red cedar. The Department of Highways uses both white and red cedar, which it obtains from areas where they are growing naturally, as well as some species usually considered as ornamental stock which it grows in its nurseries. These include mugho pine, barberry and Chinese elm. This last is the only hardwood tree used in windbreaks. It grows rapidly and its fine branching system makes it nearly as effective as an evergreen tree. The other common hardwoods such as Carolina poplar, white elm, silver maple and white ash are used fairly extensively in shelterbelts.

Snow fences are usually beneficial to crops in that they hold moisture in the fields in the form of snow in winter and reduce wind velocities and moisture loss by evaporation in summer. Occasionally they do cause ice to form over crops such as fall wheat and may be harmful in this way. The beneficial effects, however, outweigh the harmful ones so considerably that every encouragement should be given to their establishment in place of the removable type of lath fence currently in use.

CHAPTER 9

WINDBREAKS

In the process of clearing land for agriculture woodlots and belts of trees along fence lines have been removed which had served as natural shelterbelts. The restoration of these in the form of windbreaks is essential to a complete conservation program in many parts of Southern Ontario. E. I. McLoughry[1] in referring to Waterloo County states:

> "Forests and windbreaks of the county have been removed to such an extent, and the organic matter removed to such a degree, that soil drifting has become a serious problem in many areas...The policy we recommend in regard to windbreaks is to encourage the planting of desirable trees."

When proper species are used and windbreaks are correctly placed the effects are almost entirely beneficial. The effects may be direct or indirect, but in either case are the result of reduction in wind velocity. The effects of windbreaks on crops and cultivated fields may be listed as follows.

(a) Direct Effects

(1) Wind damage and lodging in small grains and corn is reduced or eliminated.

(2) Snow and the resultant moisture are more evenly distributed over fields, particularly on the higher spots where they are required most.

(3) Wind erosion of the soil is minimized.

(b) Indirect Effects

(1) Moisture loss by evaporation is reduced.

(2) Temperatures in the fields are raised, which may prevent frost damage, accelerate growth and even lengthen the growing season slightly.

(3) Erosion of the soil by water may be reduced by its more even distribution when released from snow.

The benefits of windbreaks to buildings in reducing heat loss in winter have been shown to be considerable. Experiments conducted in the United States proved that

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1. E.I. McLoughry. Proper Land Use Program of Waterloo County. 1950.

more than twice as much heat is lost from a house, per day or per hour, with a wind of 20 m.p.h. as with one of 5 m.p.h., and a windbreak can easily reduce wind velocities in this proportion. Used in this way they can often be made to form an effective background for the house and a protection for farm buildings. Another advantage of windbreaks is that they provide shelter and runways for insectivorous birds and small animals.

Belts of trees comprising one or two rows are usually called windbreaks, and with more than two rows, shelterbelts. In Southern Ontario windbreaks as a rule give sufficient protection except where wind erosion of soil on rolling land is severe, when shelterbelts may be required. On level land windbreaks may nearly always be established along existing fence lines, but on rolling land consideration should be given to the contour of the land. The prevailing winds in Southern Ontario are generally from the west, so that the greatest protection will be derived from windbreaks on the west side, but the placement of windbreaks on the other three sides as well should be considered.

Both the height of the trees and the wind velocity influence the effective range of a windbreak. An average windbreak will reduce the ground velocity of a 20-mile wind 10 percent or more for a distance of about 30 times the height of the trees. About one-fourth of this effect will be felt on the windward side of the windbreak and three-fourths on the leeward side. For example, if the trees are 40 feet high the total effective range with a 20-mile wind will be 30 x 40 or 1,200 feet, 300 feet of which will be on the windward side and 900 feet on the leeward side. Generally speaking, the reduction in velocity is greatest close to the windbreak and tapers out to zero further away. With higher wind velocities and/or higher trees the proportionate reduction and the effective range will be greater.

A windbreak not only reduces the velocity of wind striking it but also slightly increases the velocity of the wind diverted over, round or through it if there are gaps. The increase in velocity of winds passing over it increases its effectiveness somewhat but the increase in velocity of winds passing round or through it will increase the damage caused. For example, snow drifts will form at these points (see chapter on Snow Fences).

On level land in Southern Ontario windbreaks completely surrounding each farm of 100 acres would normally give adequate protection except for light rolling land and such wind-sensitive crops as tobacco. These should be on the west side of north-south roads, but on east-west roads would have to be carefully placed on the north or south sides, depending on the direction of the local prevailing winds. On land which is not level at least the same proportion of windbreak to area should be provided, but in many cases this would have to be adjusted according to the local topography. That is, the trees should be planted on suitable contours and where hilltops or slopes are eroding badly it will be necessary to establish plantations over a large part of the eroding area. The windbreaks should, of course, be tied in with plantations and existing woodland so that where these exist additional protection would not be required.

Since density, both in winter and summer, is one of the prime requisites of a good windbreak, the conifers in most instances make the best windbreaks. The slower-growing species such as white cedar and spruce give most protection, but the faster-growing ones such as the pines have the advantage of attaining more effective heights in a shorter time. A number of broad-leaved trees have fine, dense branching habits and may be nearly as effective as conifers if the branches are maintained down to the ground; among these may be included sugar-maple, Chinese elm and European alder.

European alder is gaining great popularity as a windbreak tree because it is a nitrogen-fixer like the legumes and does not rob the soil to the same extent as non-nitrogen-fixing species. In fact, tobacco is frequently planted close to it with little loss in size or vigour of the plants. As the robbing of the soil is one of the severest criticisms levelled against windbreaks, consideration should also be given to the planting of such leguminous trees as honey locust and caragana on certain sites.

One consideration that should be kept in mind is that under certain circumstances windbreaks may cause air stagnation, which may increase temperature and moisture conditions to a dangerous degree in summer or increase frost damage in spring and fall on small areas, particularly in hollows. Where this is likely to occur, windbreaks should be planted so as to guide the flow of air past such spots. Where these conditions develop after the windbreaks are established they may be relieved by judicious opening up of the windbreaks.

Experience has shown that windbreaks are an asset to any farm, that their adverse effects, if any, are local and easily remedied, and that in many areas they are essential to the control of soil erosion by wind. It is therefore recommended that the Authority encourage the establishment of windbreaks by private owners in every way.

Ontario. Planning and Development,
... Dept. of

(In pocket of.)

NATURAL WATER STORAGE AREAS REFORESTATION LAND AND EXISTING WOODLAND

CATFISH CREEK WATERSHED

report.

ONTARIO DEPARTMENT OF PLANNING AND DEVELOPMENT

CONSERVATION BRANCH

NATURAL WATER STORAGE AREAS REFORESTATION LAND AND EXISTING WOODLAND

1950

LEGEND

EXISTING WOODLAND

SCRUB LAND WS – WET SCRUB, DS – DRY SCRUB

NATURAL WATER STORAGE AREAS

SCALE – MILES

1 3/4 1/2 1/4 0 1 2

ONTARIO DEPARTMENT OF PLANNING AND DEVELOPMENT

CONSERVATION BRANCH

FOREST COVER TYPES

TYPE NO.	TYPE NAMES
4	ASPEN
8	WHITE PINE - RED OAK - WHITE ASH
9	WHITE PINE
10	WHITE PINE - HEMLOCK
11	HEMLOCK
12	SUGAR MAPLE - BEECH - YELLOW BIRCH
13	SUGAR MAPLE - BASSWOOD
14	SUGAR MAPLE
14A	BLACK CHERRY
24	WHITE CEDAR
25	TAMARACK
26	BLACK ASH - WHITE ELM - RED MAPLE
45	BUR OAK
49	WHITE OAK - BLACK OAK - RED OAK
49A	WHITE OAK - BLACK OAK - HICKORY
50	WHITE OAK
51	RED OAK - BASSWOOD - WHITE ASH
57	BEECH - SUGAR MAPLE
58	BEECH
59	ASH - HICKORY
60	SILVER MAPLE - WHITE ELM
60A	WHITE ELM
88	WILLOW
P	PLANTATION

NATURAL WATER STORAGE AREAS

1. BROWNSVILLE
2. GLENCOLIN
3. SUMMERS
4. SPRINGWATER
5. JAFFA
6. SPARTA
7. PORT BRUCE